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(12) **United States Patent**
Maekawa

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(45) **Date of Patent: Aug. 23, 2011**

(54) **DISPLAY DEVICE PROVIDED WITH SEMICONDUCTOR ELEMENT AND MANUFACTURING METHOD THEREOF, AND ELECTRONIC DEVICE INSTALLED WITH DISPLAY DEVICE PROVIDED WITH SEMICONDUCTOR ELEMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jul. 12, 2010**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 20, 2004 (JP) 2004-241119

(51) **Int. Cl.**
H01L 21/336 (2006.01)

(52) **U.S. Cl.** **438/34**; 438/99; 438/149

(58) **Field of Classification Search** 438/34, 438/99, 149

See application file for complete search history.

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Primary Examiner — Long Pham

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(57) **ABSTRACT**

According to one feature of the invention, a region of an insulating film surface at least overlapped with a part of a gate electrode or wiring is coated with an organic agent; a fluid in which conductive fine particles are dispersed in an organic solvent is discharged by a droplet discharging method in the insulating film surface ranging from a region where the organic agent is coated and left to a region where the organic agent is not coated. The organic agent is coated to improve wettability of the fluid in the insulating film surface, and one of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curve therebetween is formed by being curved in a concave and the other end is formed by being curved in a convex.

18 Claims, 13 Drawing Sheets

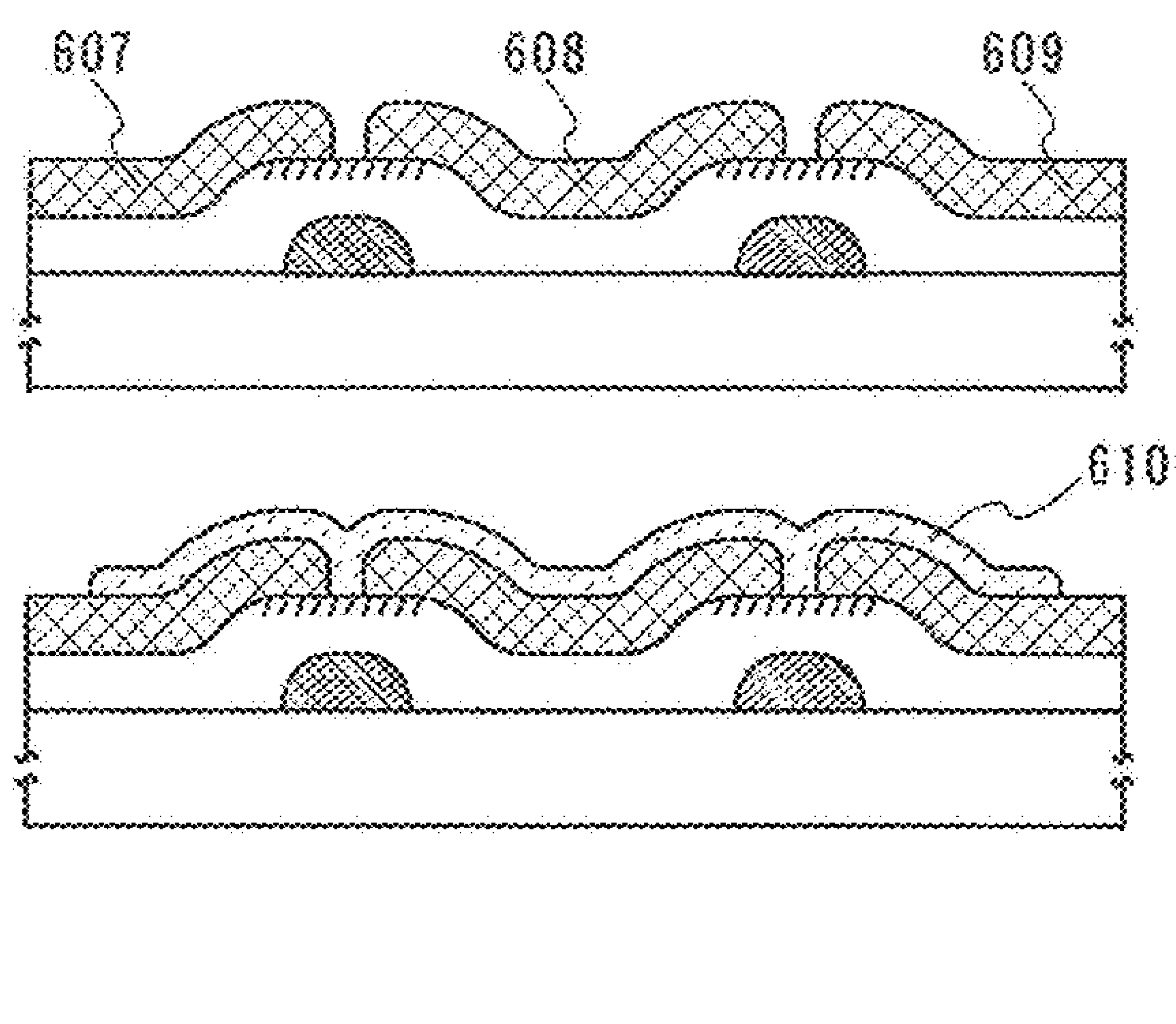

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FIG. 1A

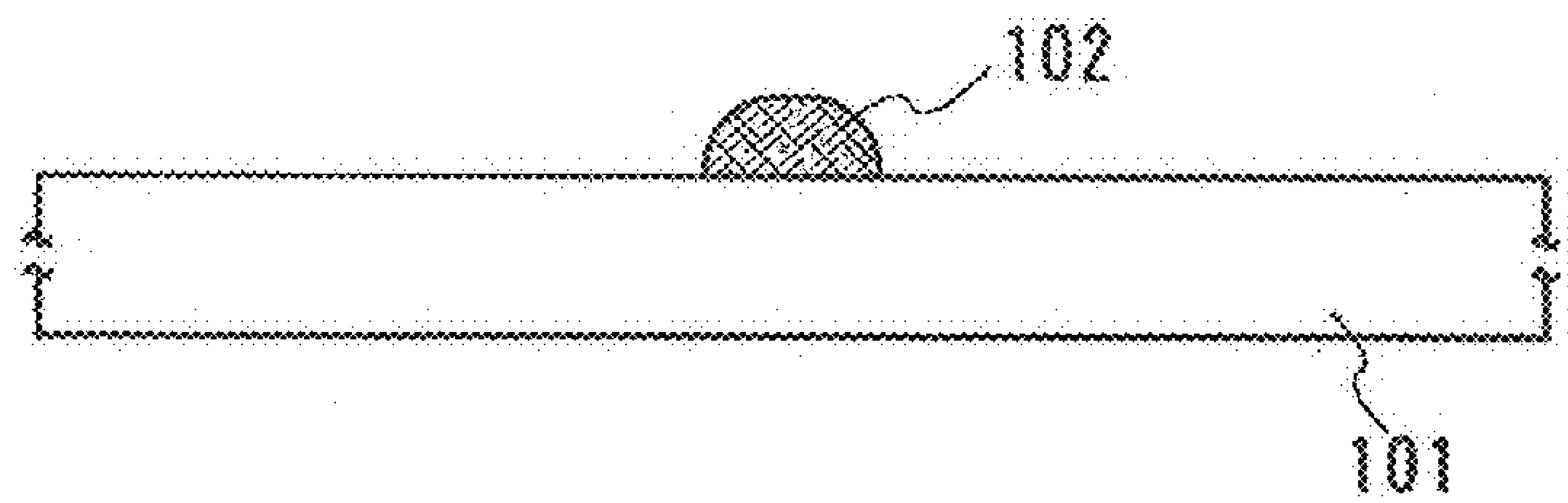


FIG. 1B

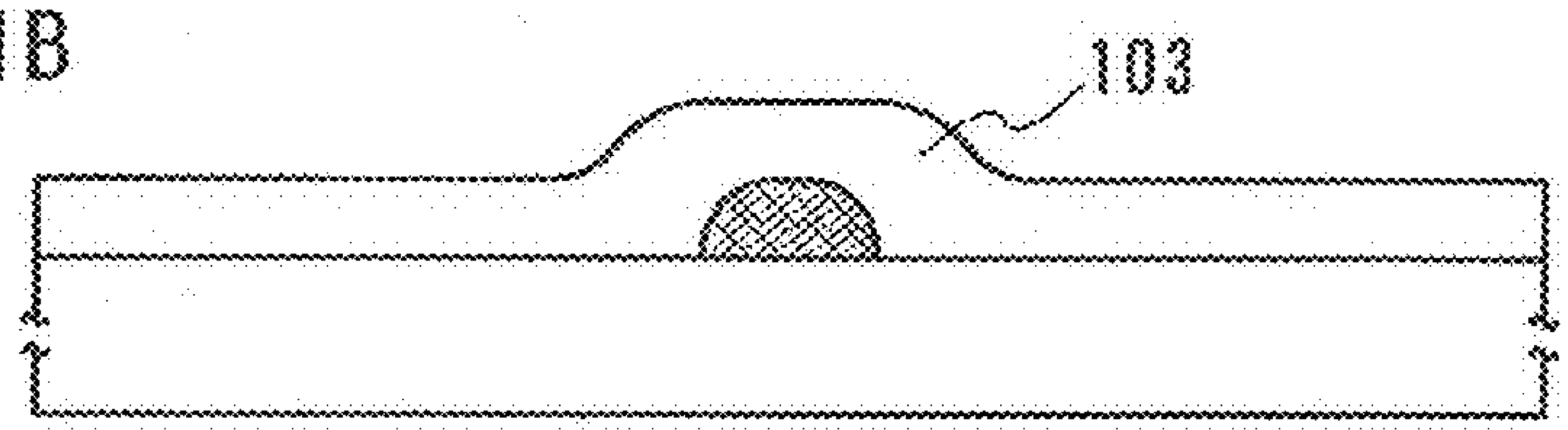


FIG. 1C

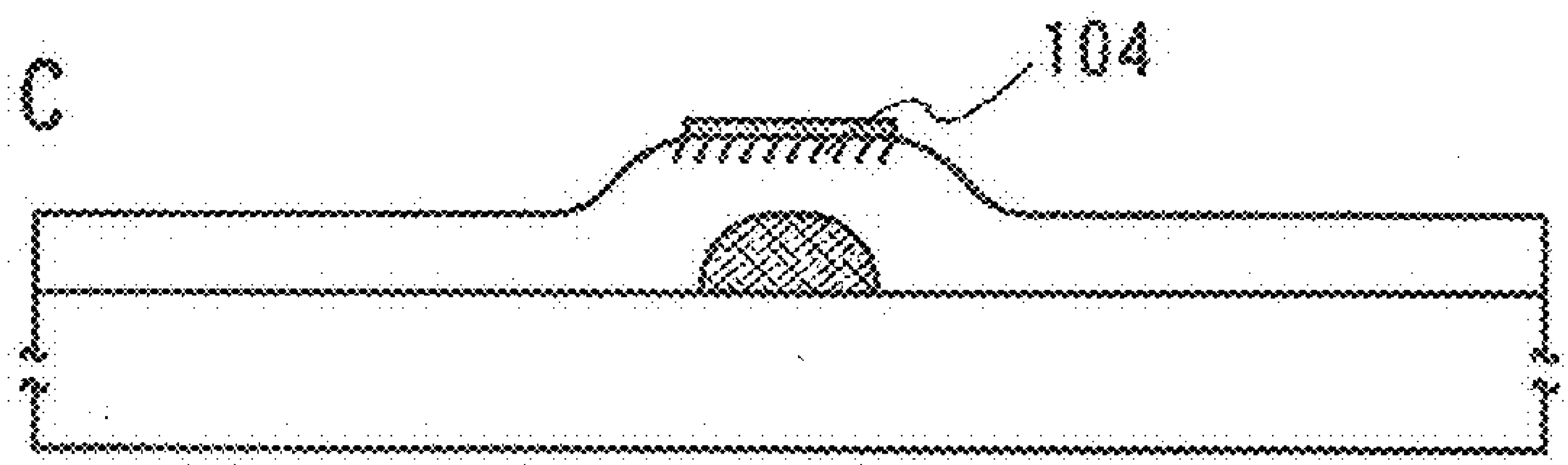


FIG. 1D

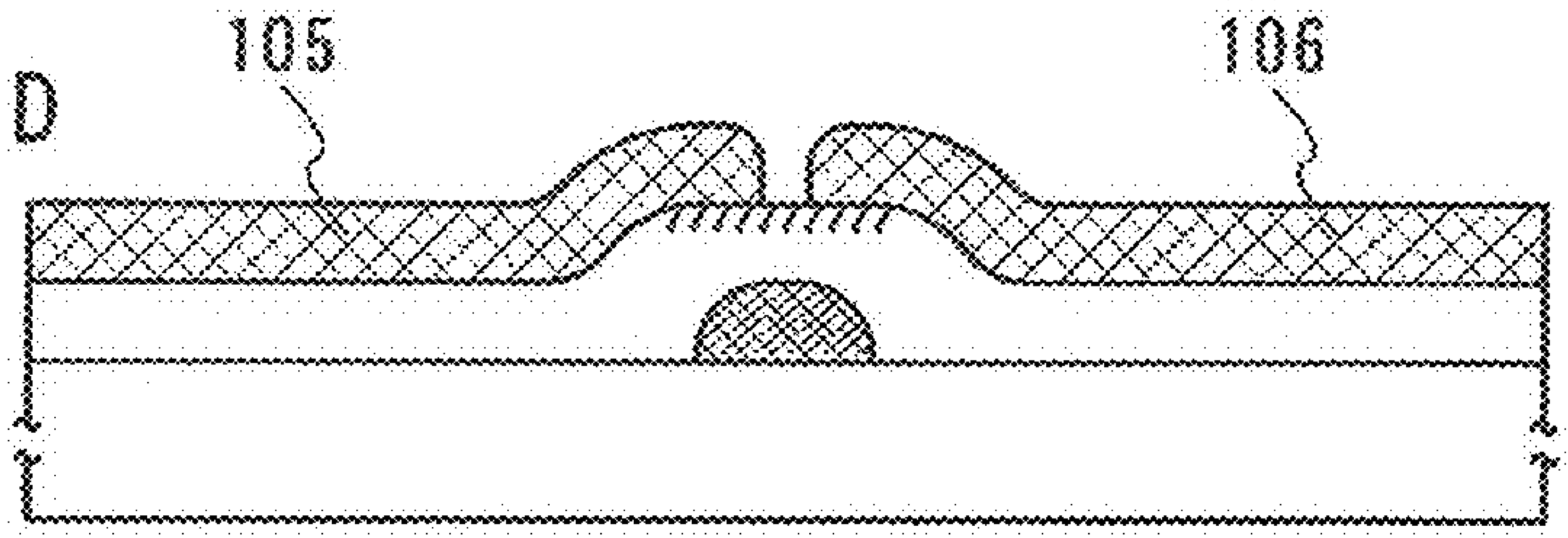


FIG. 1E

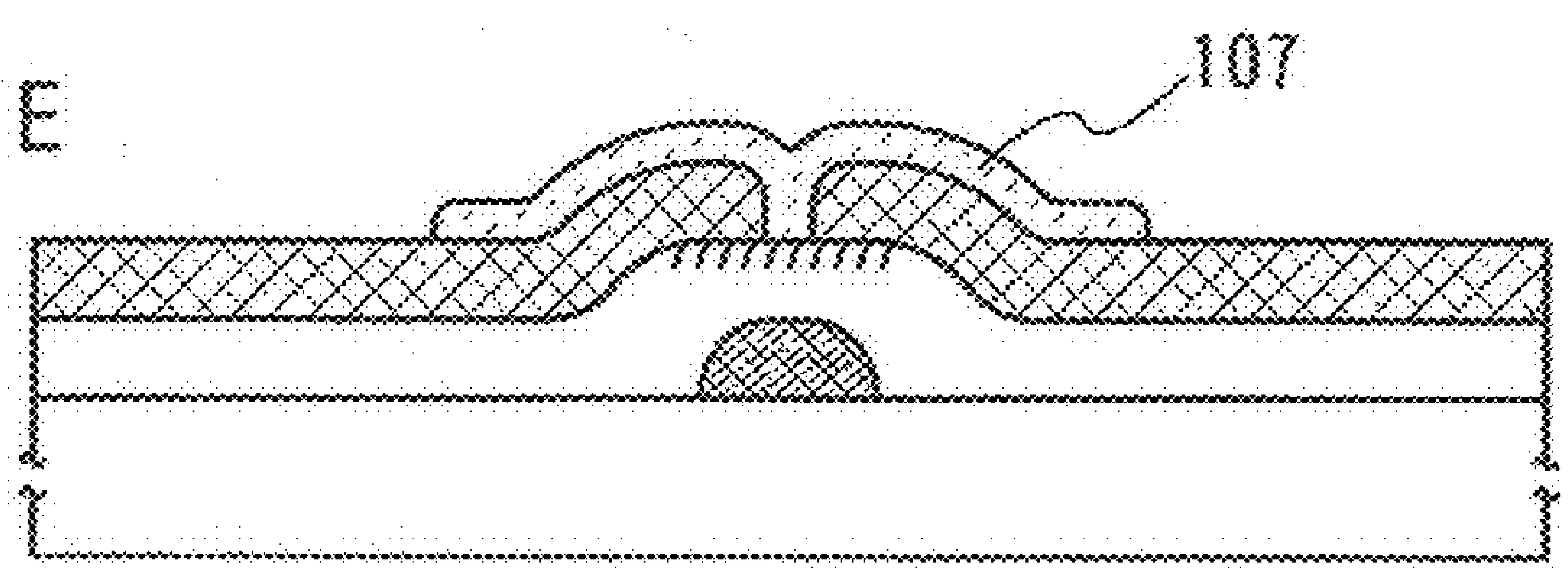


FIG. 2A

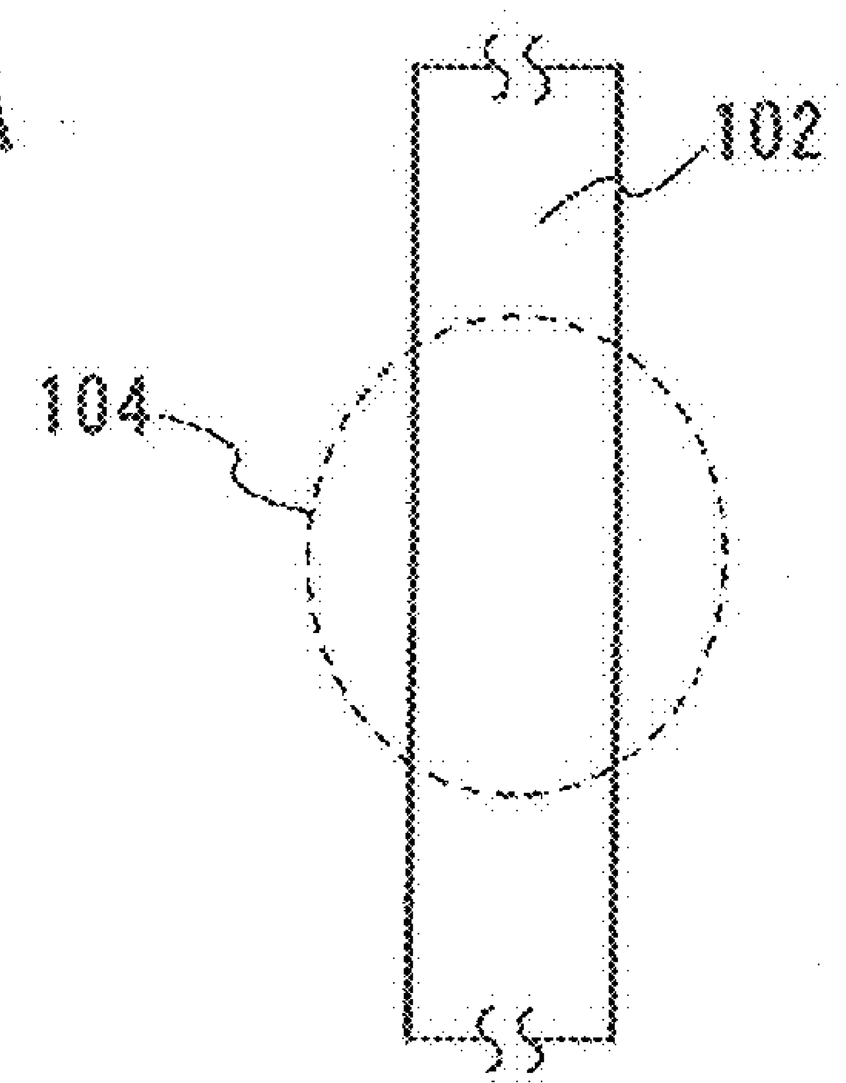


FIG. 2B

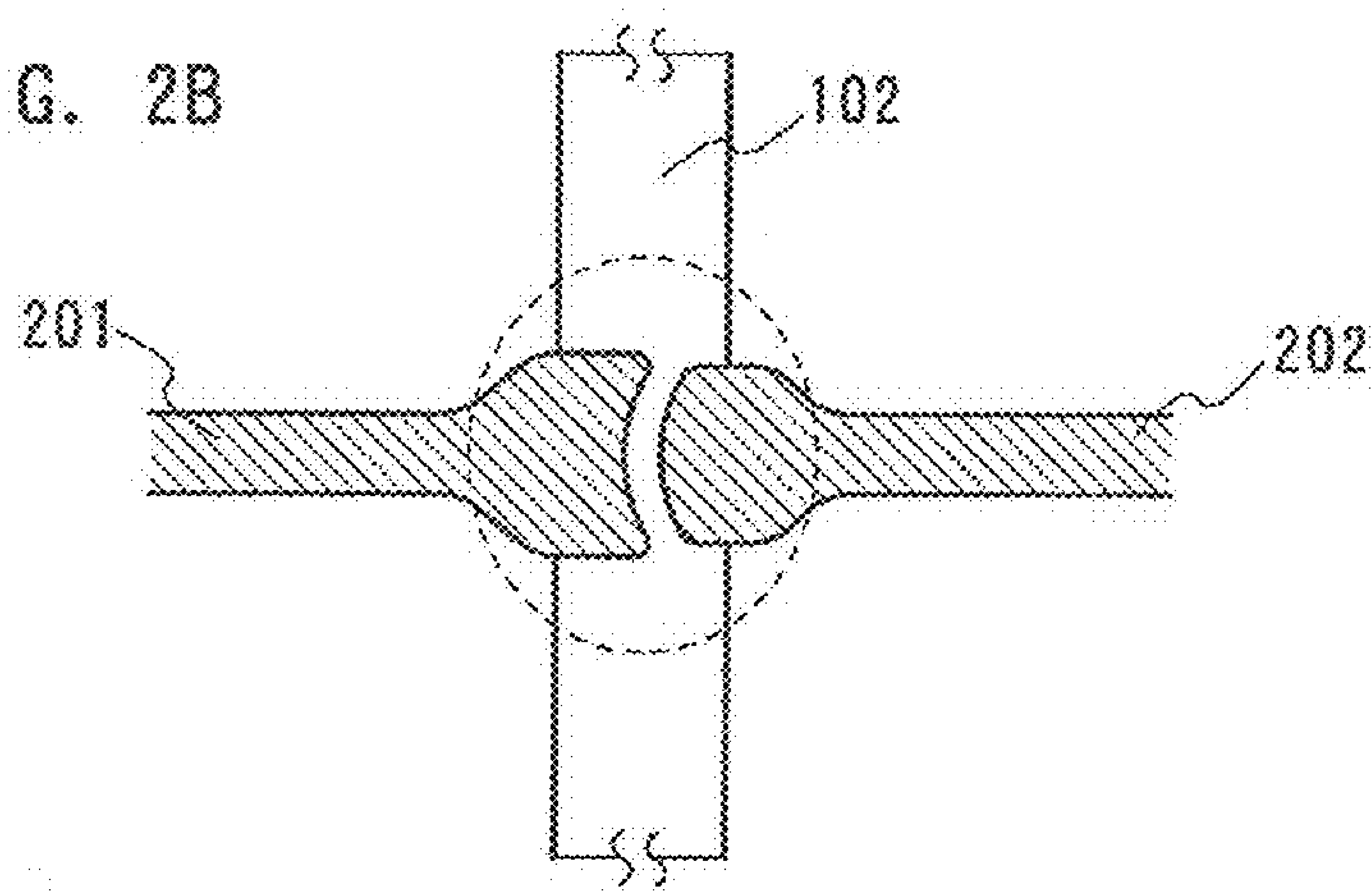


FIG. 2C

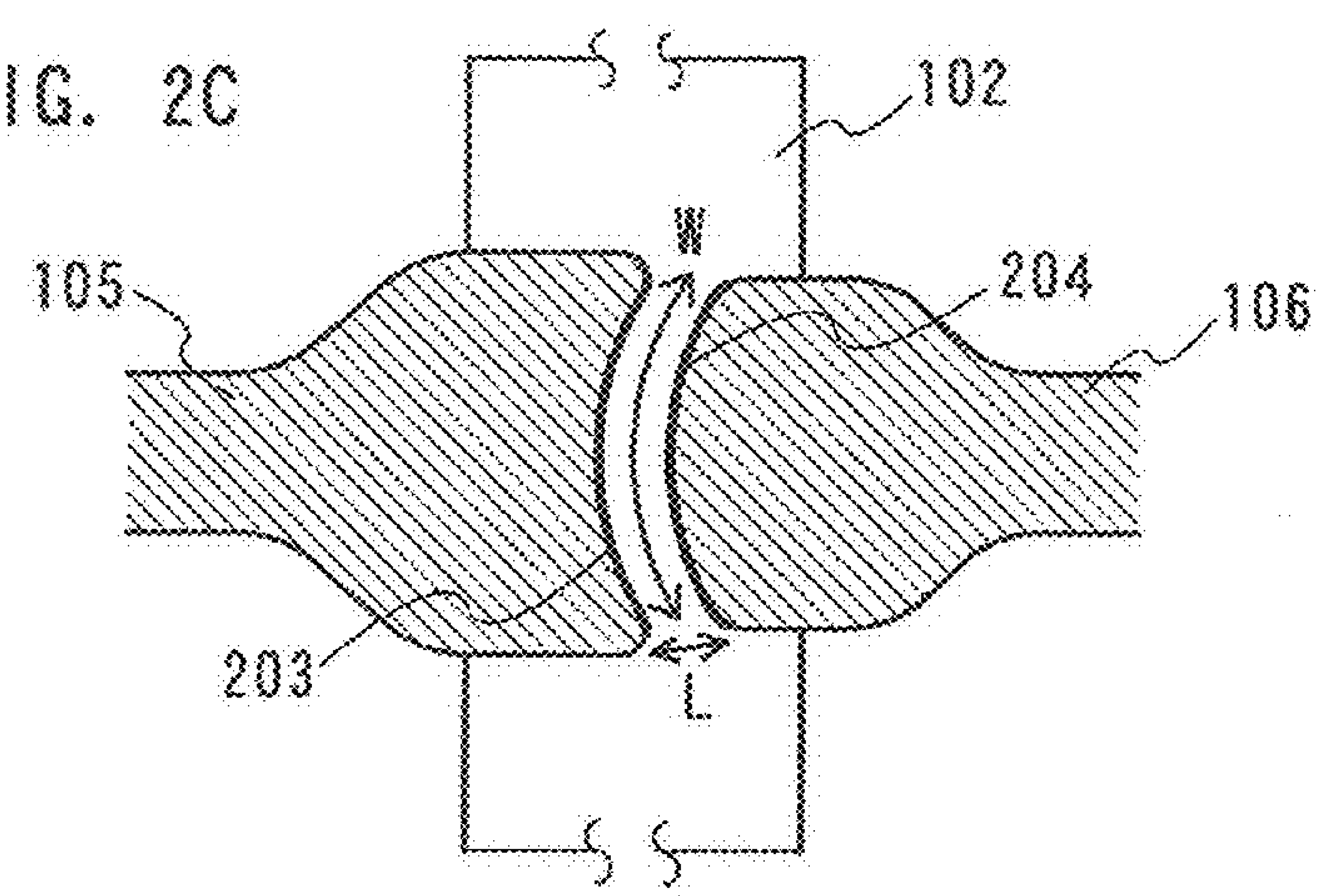


FIG. 3A

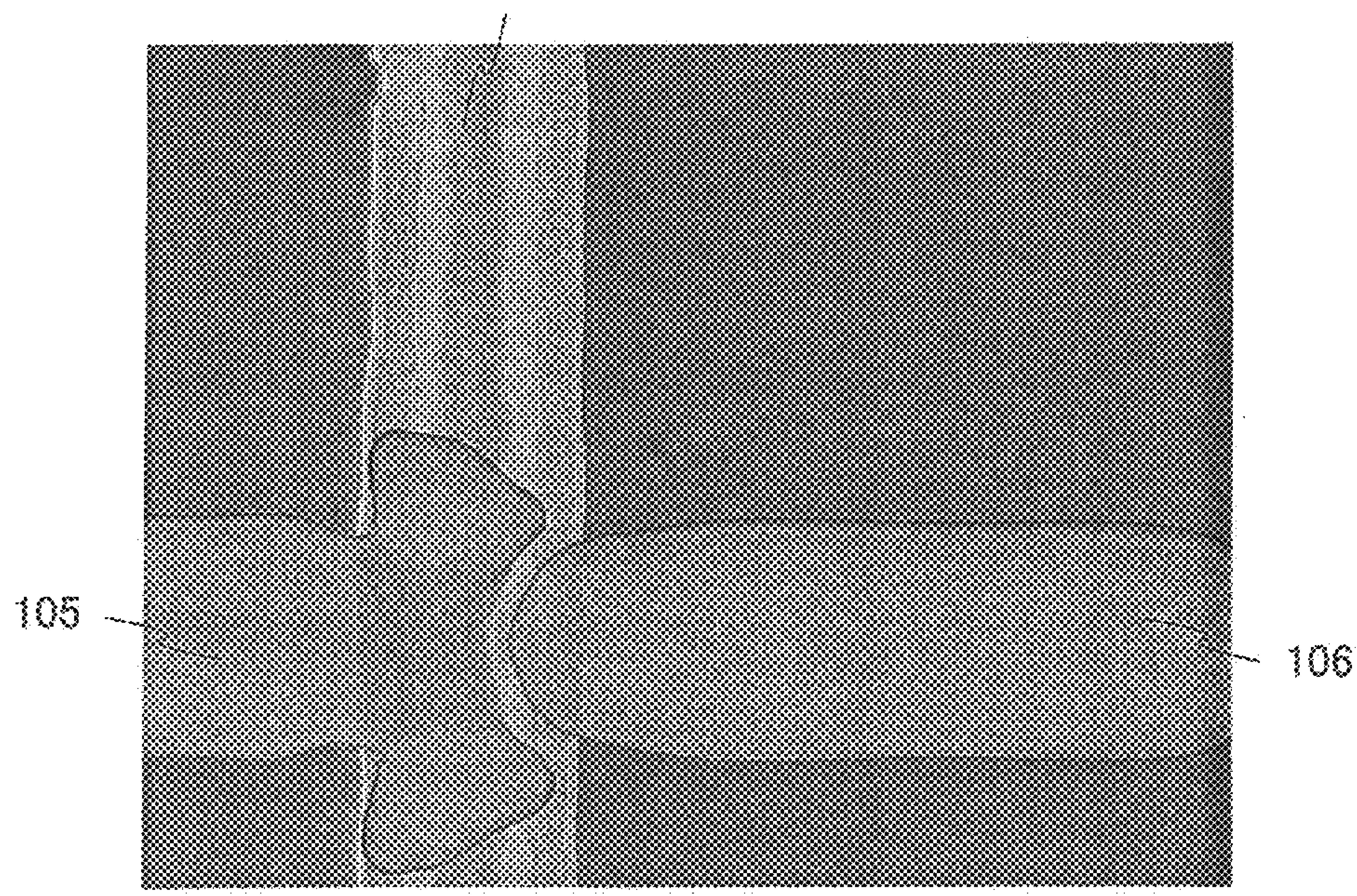
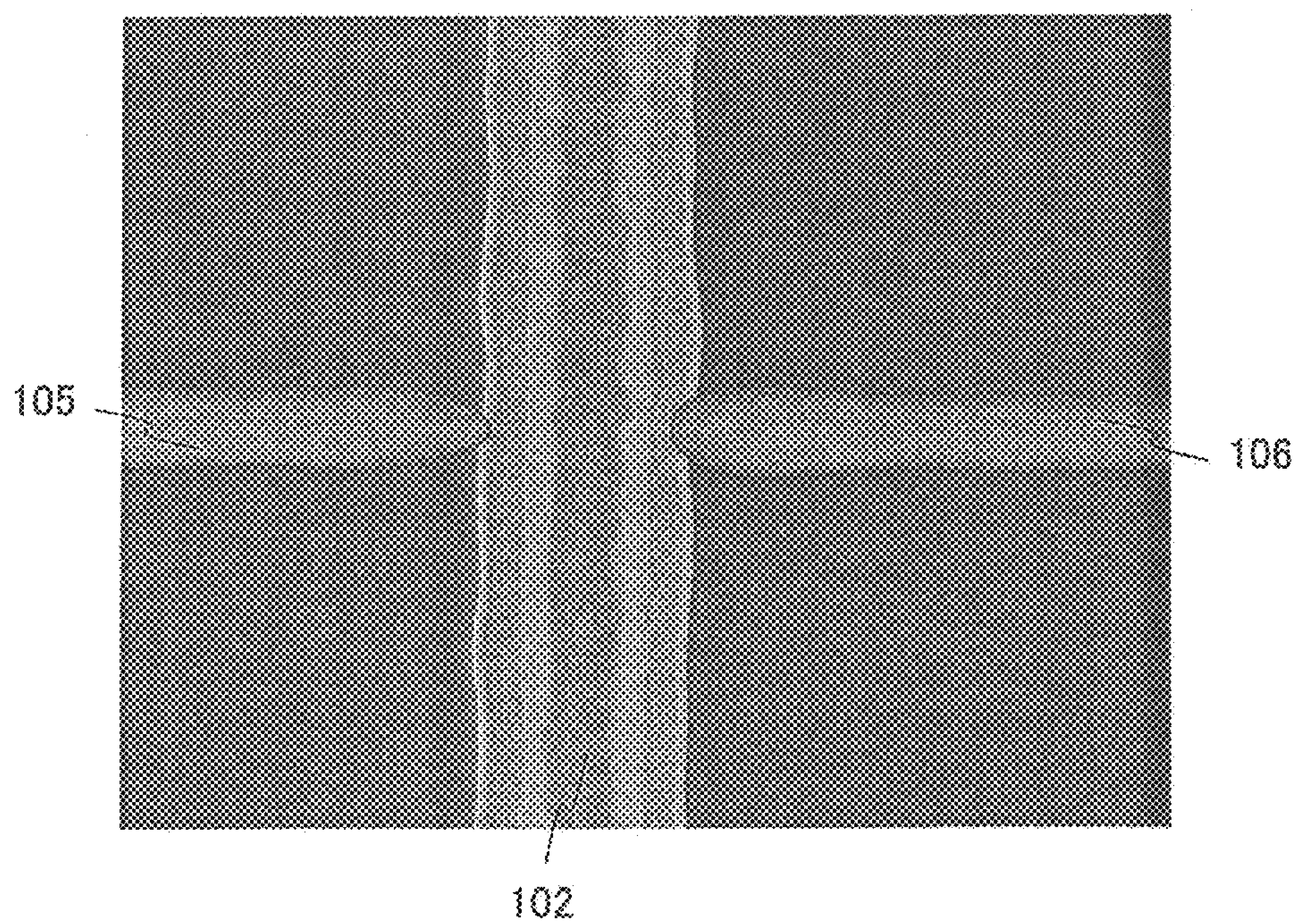
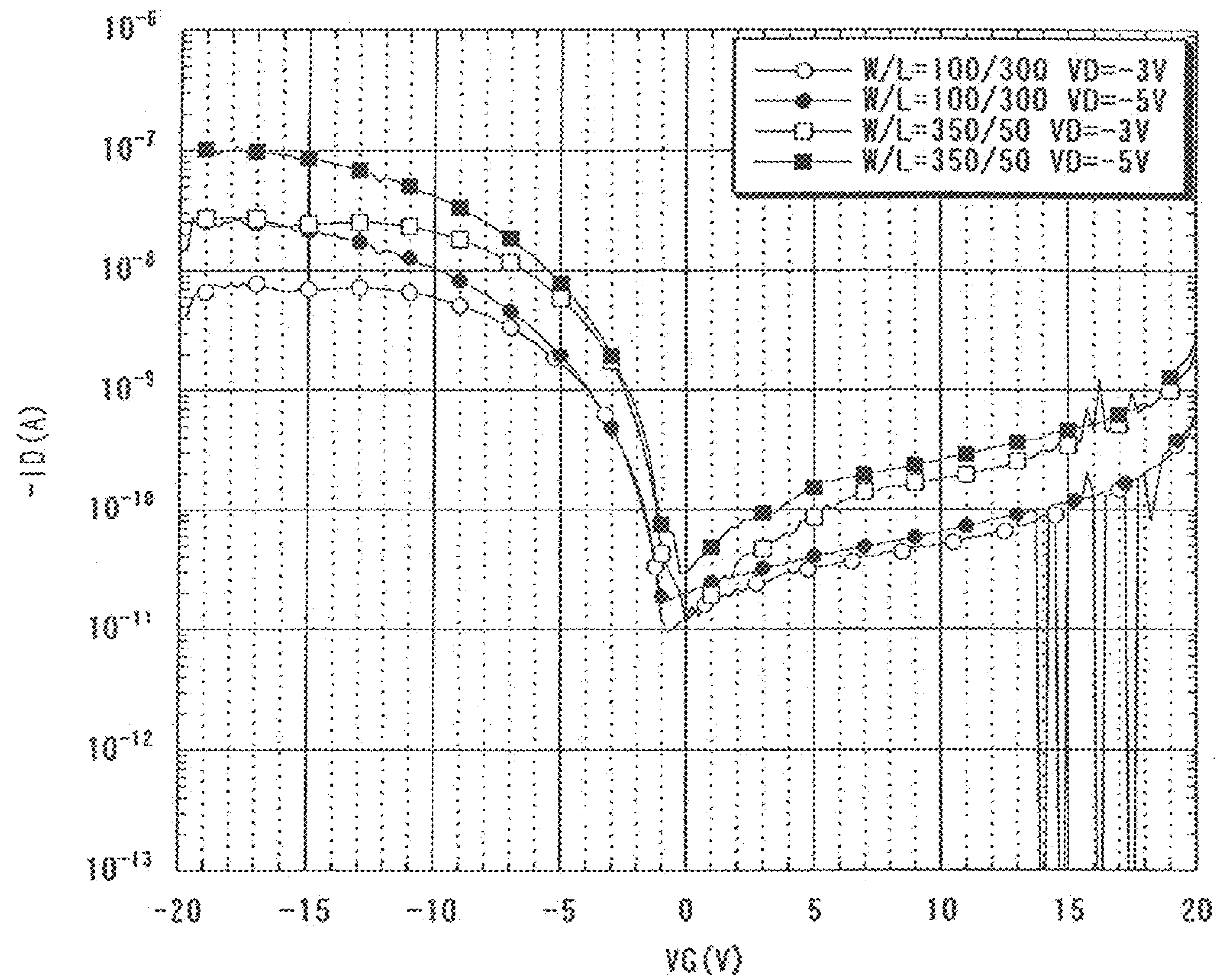


FIG. 3B





W/L=100/300 VD=-3V
W/L=100/300 VD=-5V
W/L=350/50 VD=-3V
W/L=350/50 VD=-5V
-ID(A)
VG(V)

FIG. 4

FIG. 5A

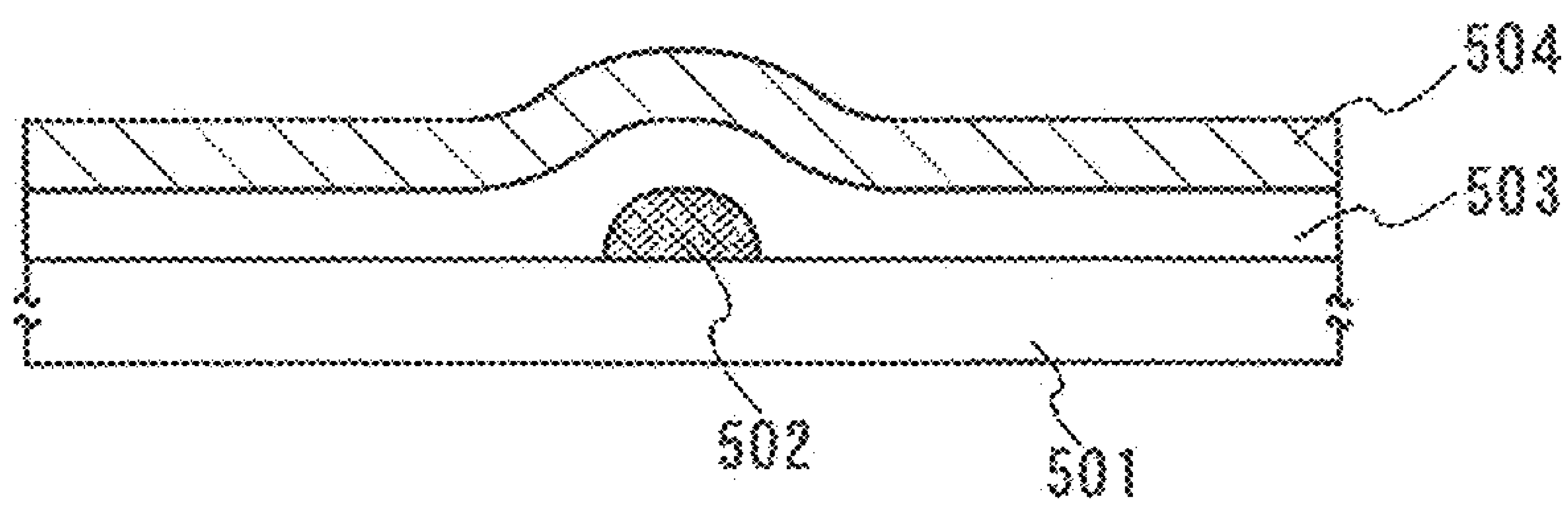


FIG. 5B

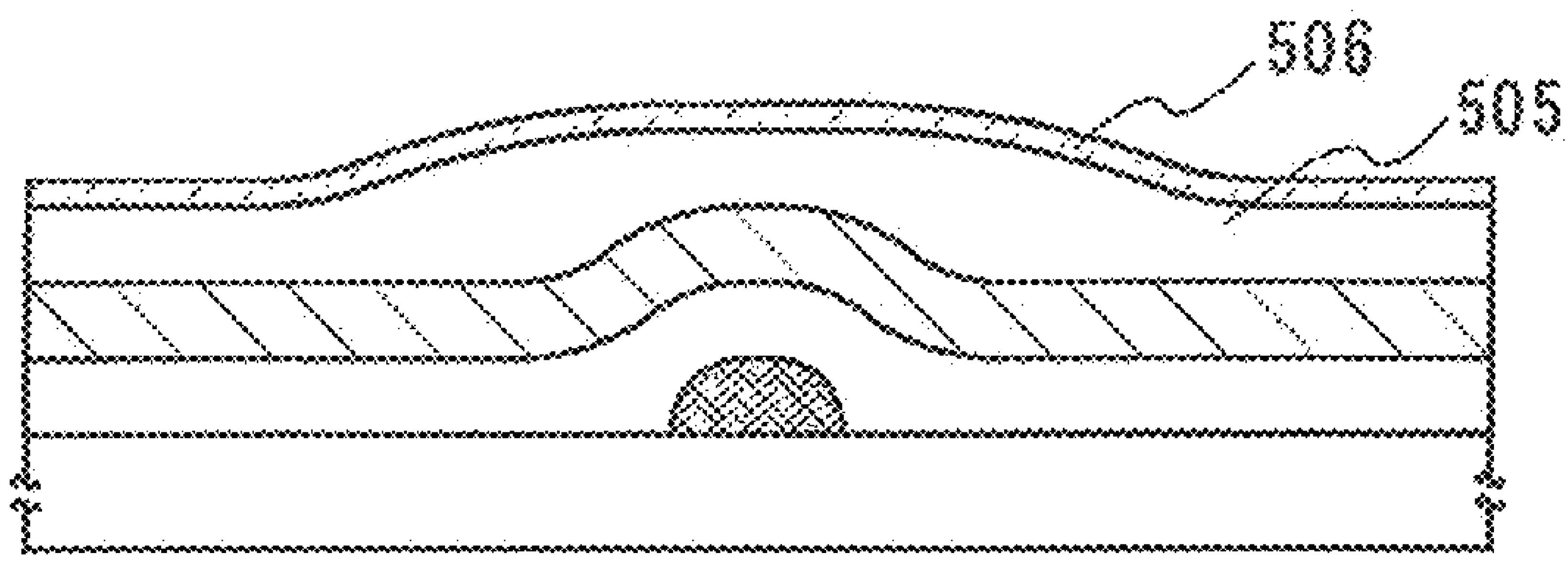


FIG. 5C

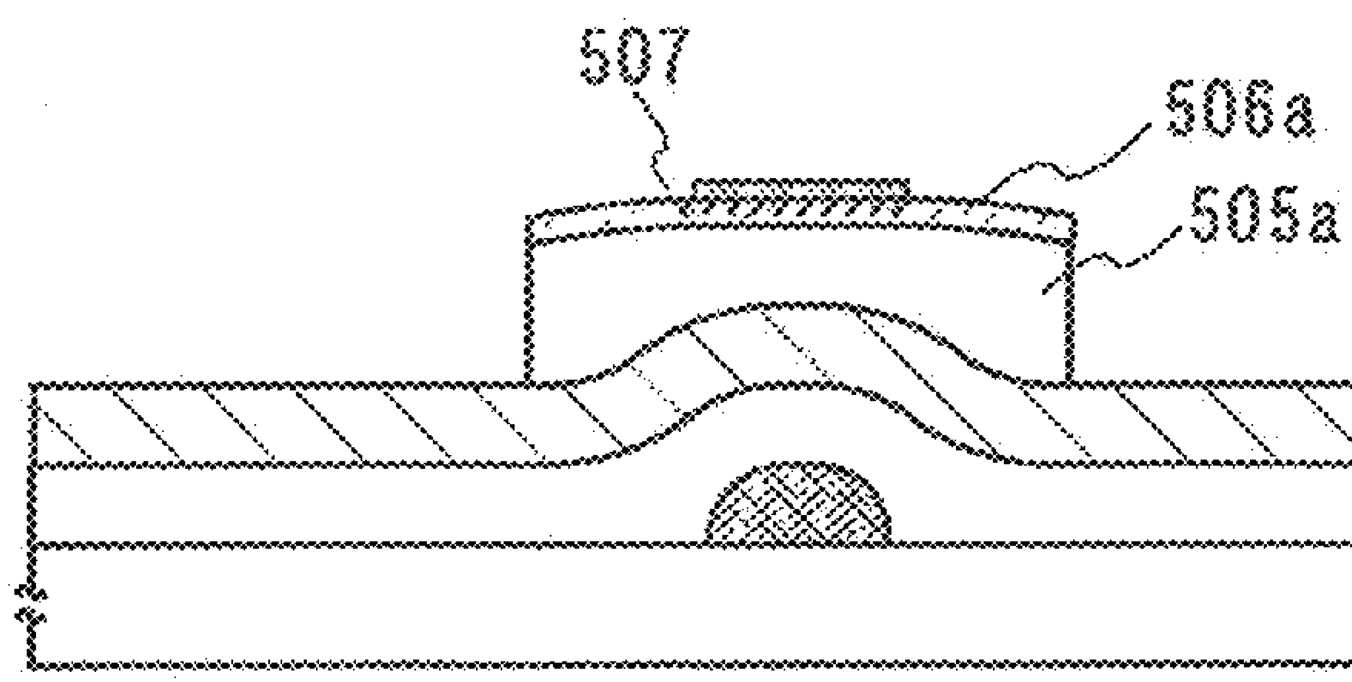


FIG. 5D

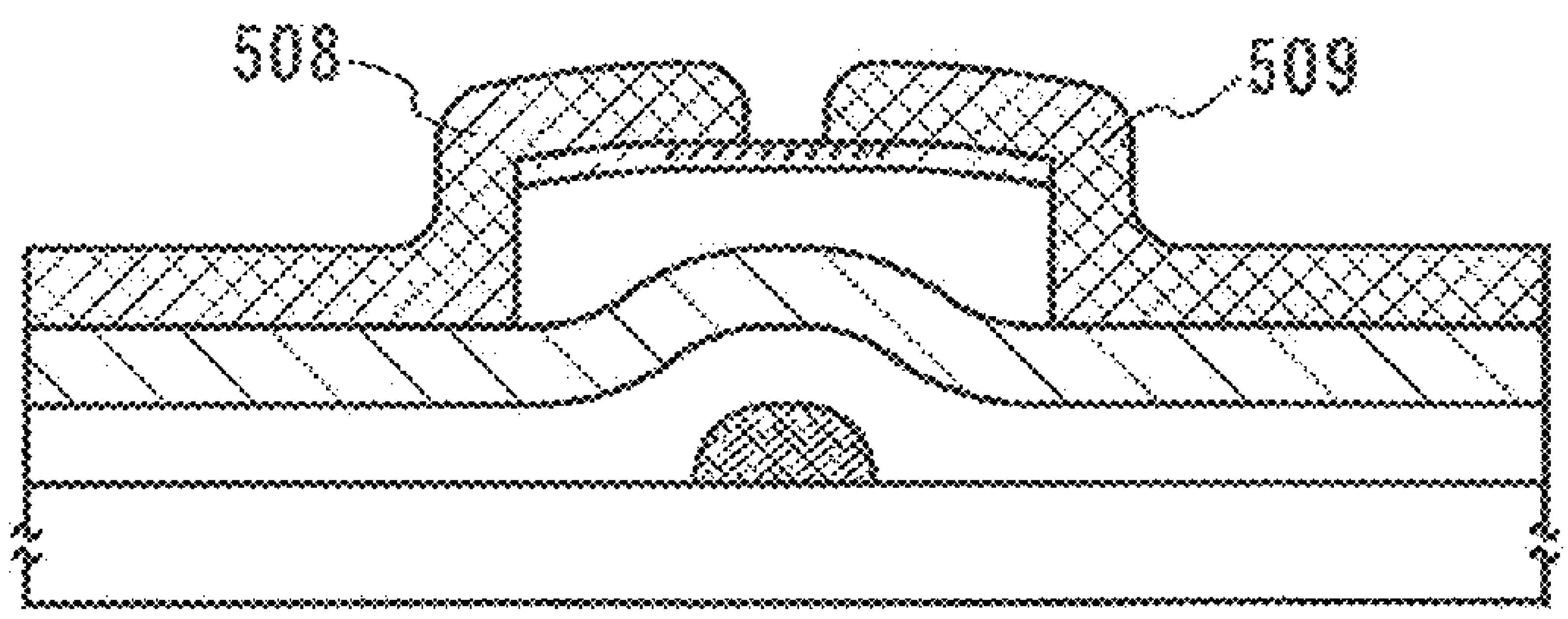


FIG. 5E

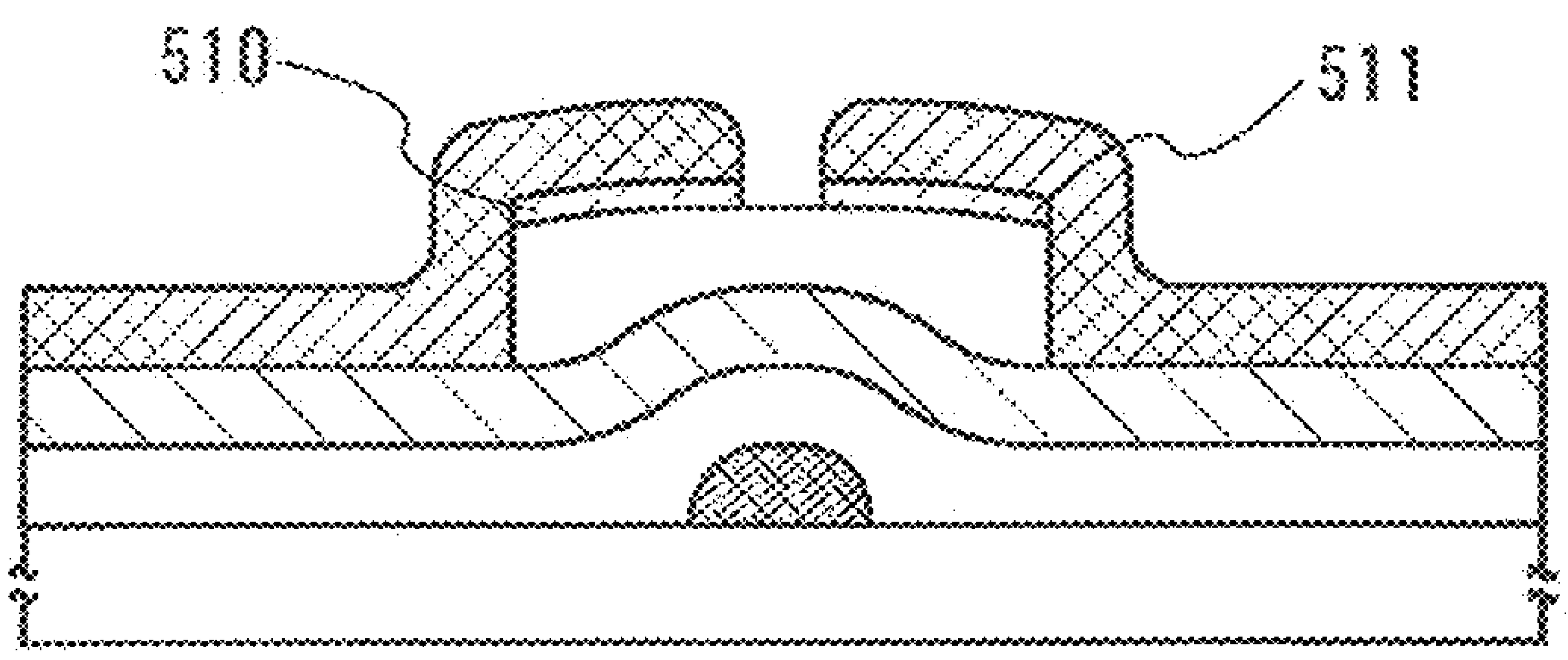


FIG. 6A

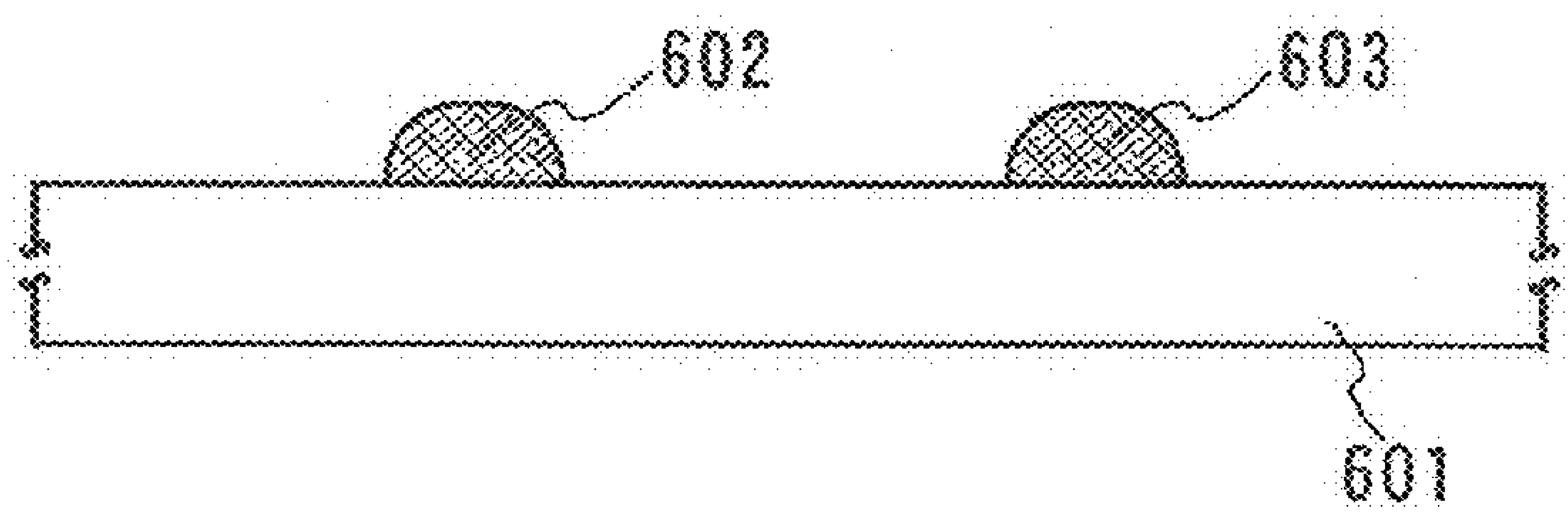


FIG. 6B

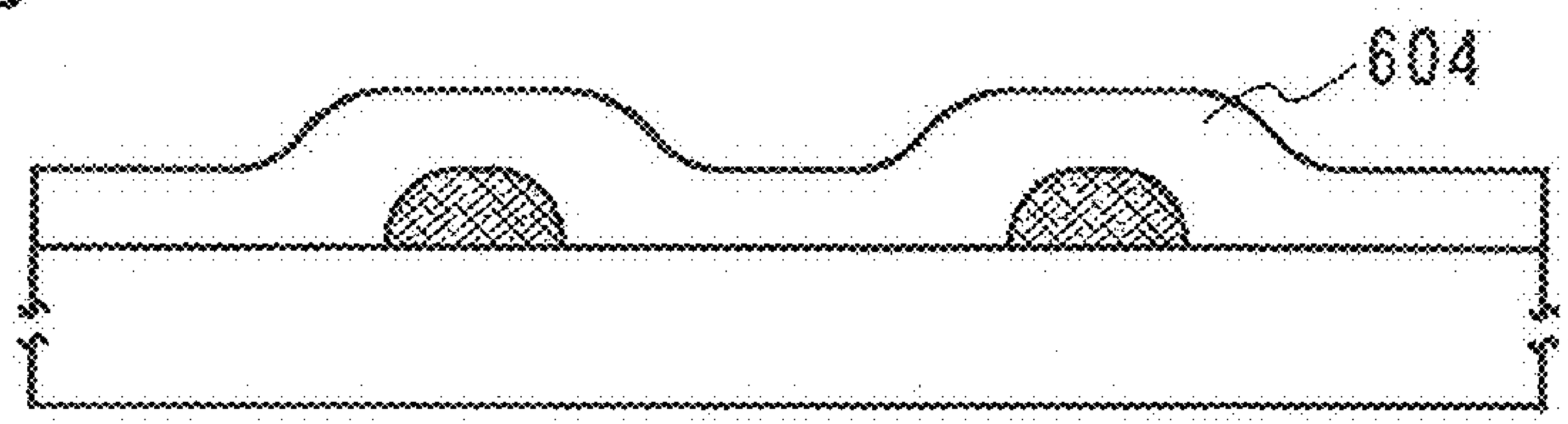


FIG. 6C

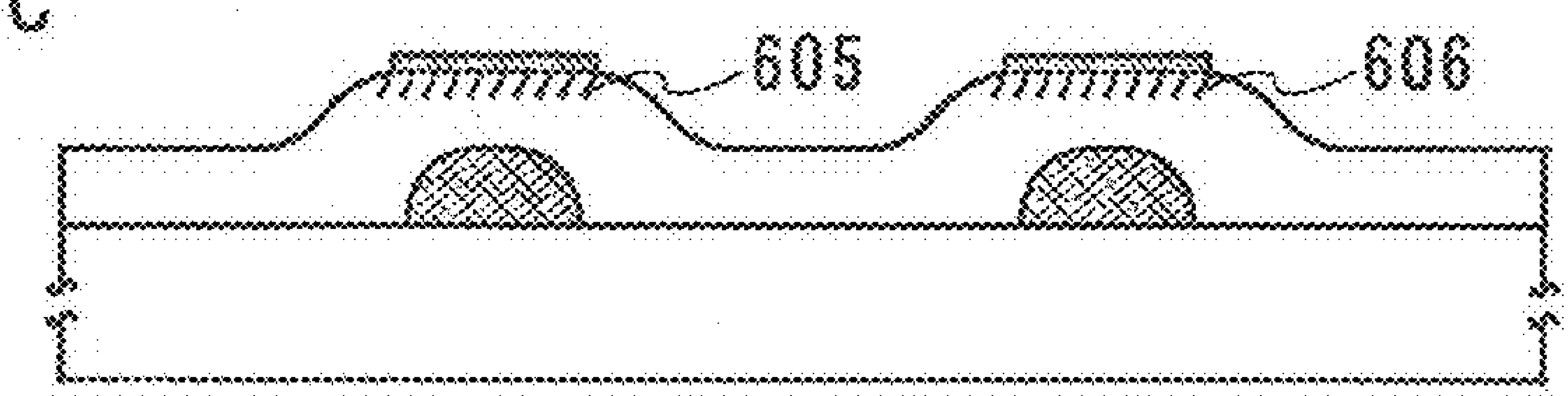


FIG. 6D

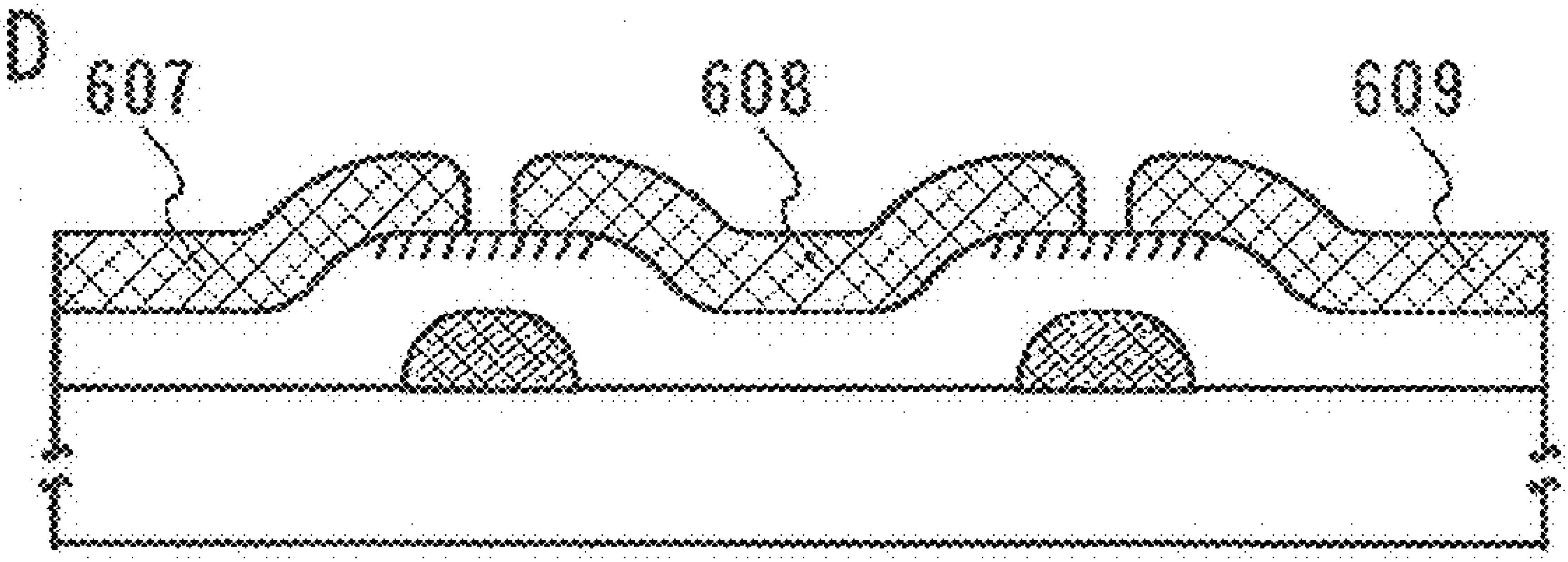


FIG. 6E

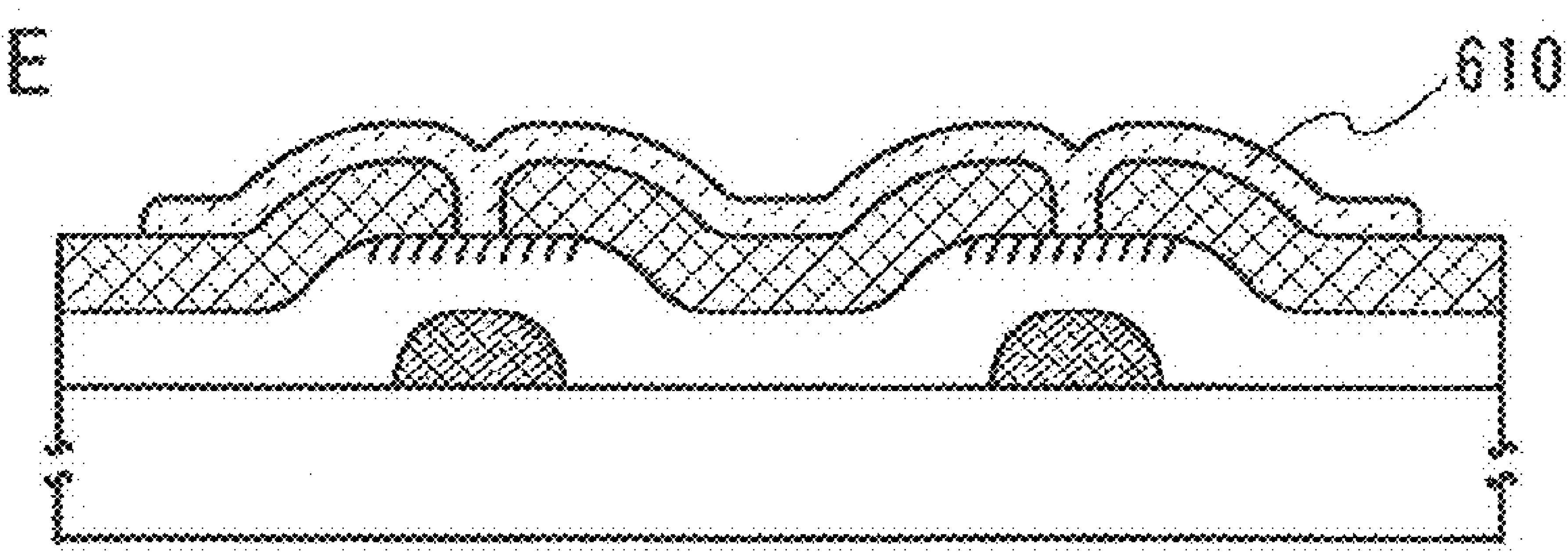


FIG. 7A

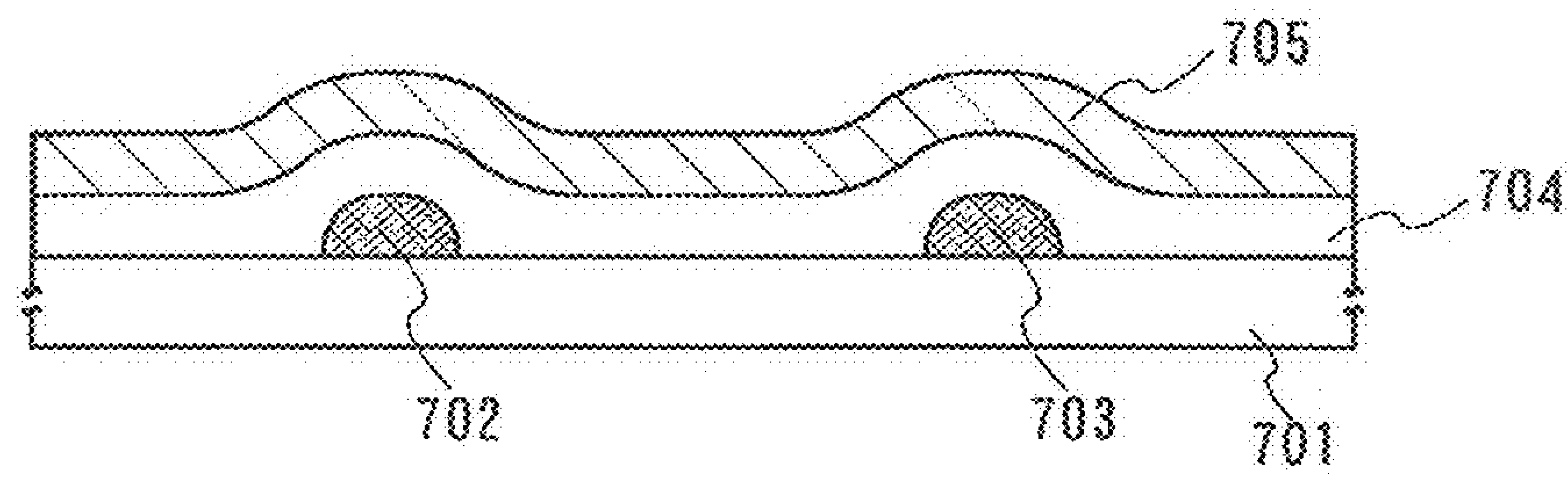


FIG. 7B

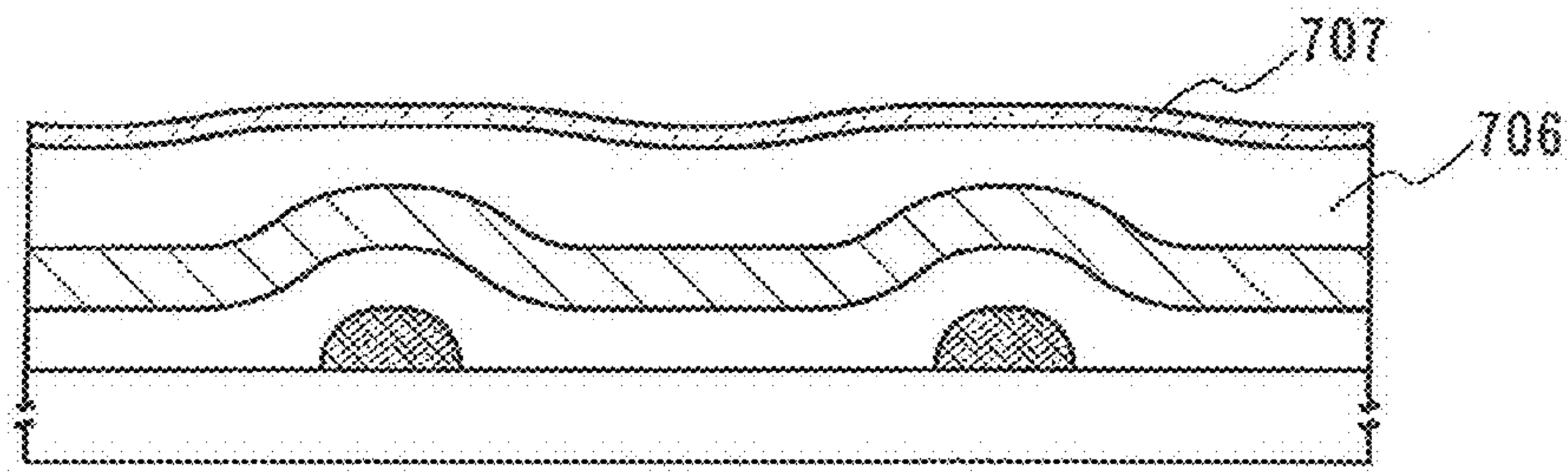


FIG. 7C

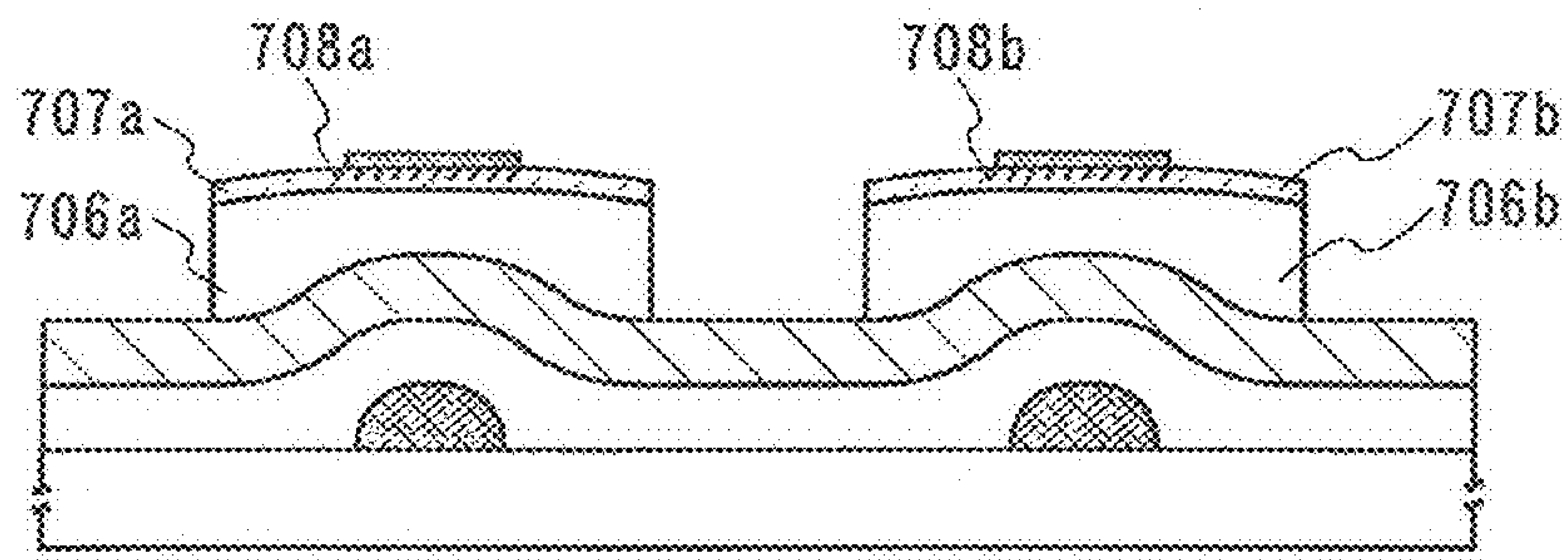


FIG. 7D

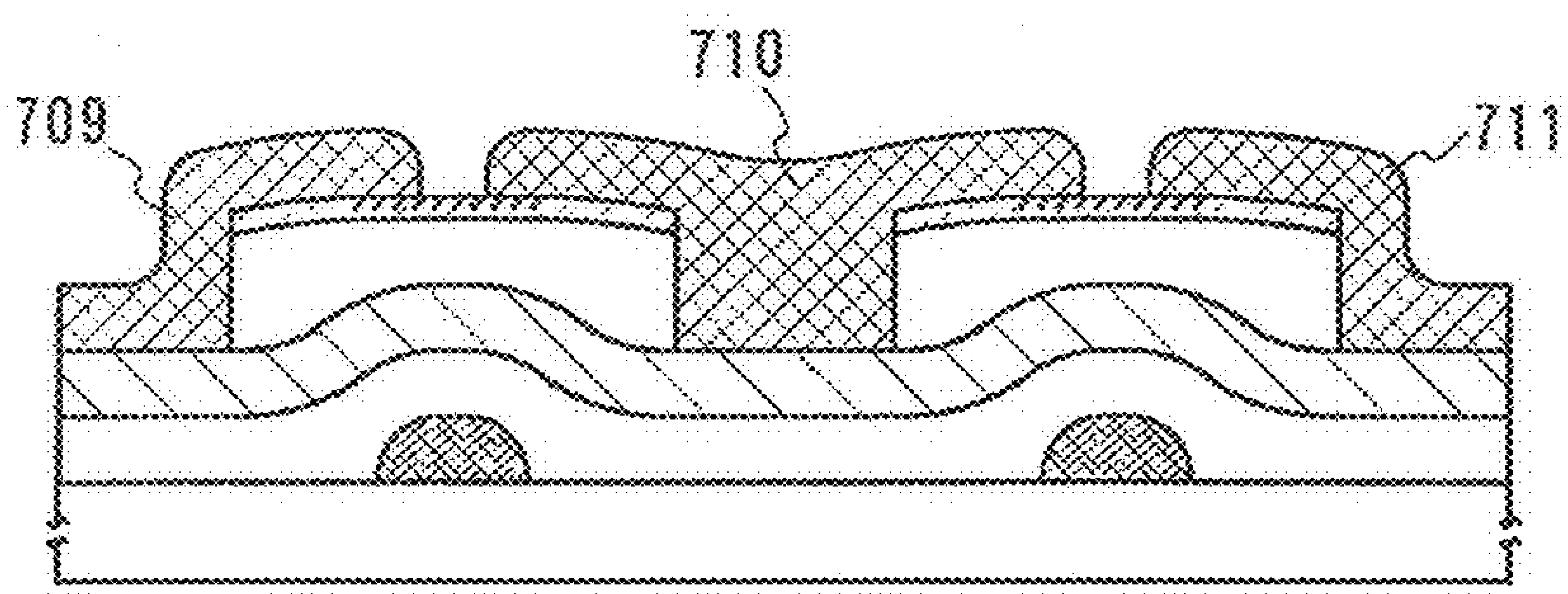


FIG. 7E

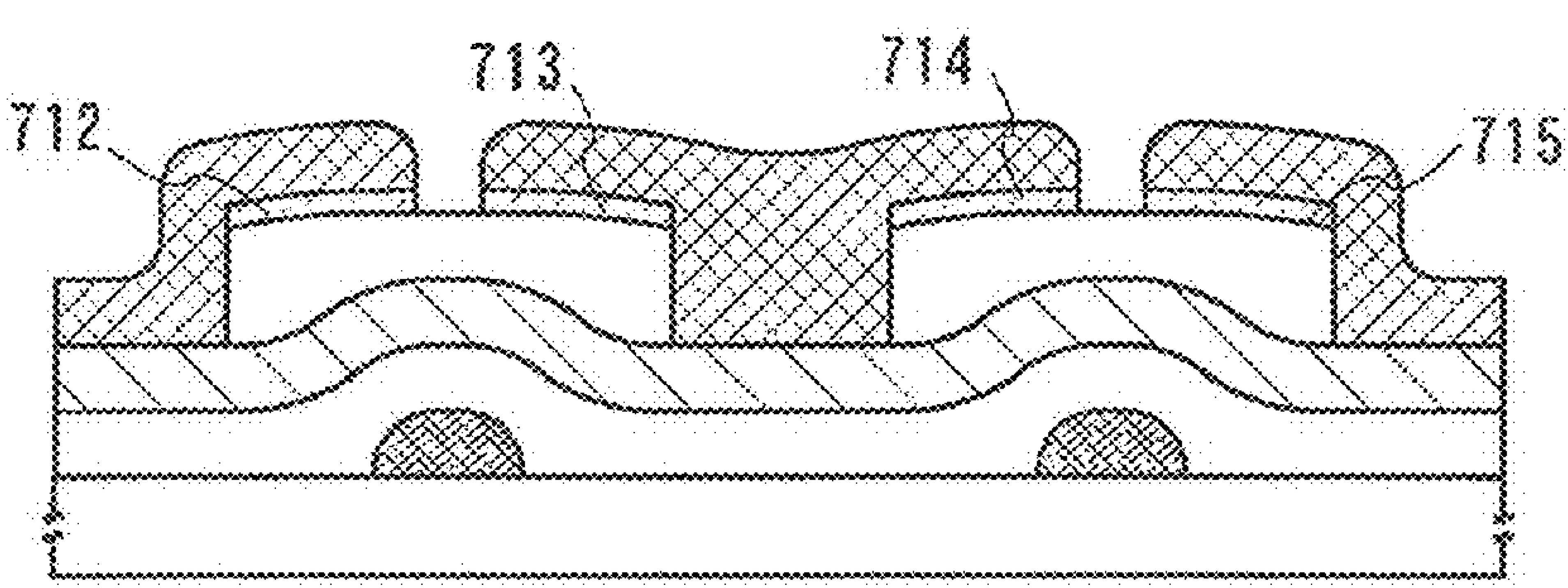


FIG. 8A

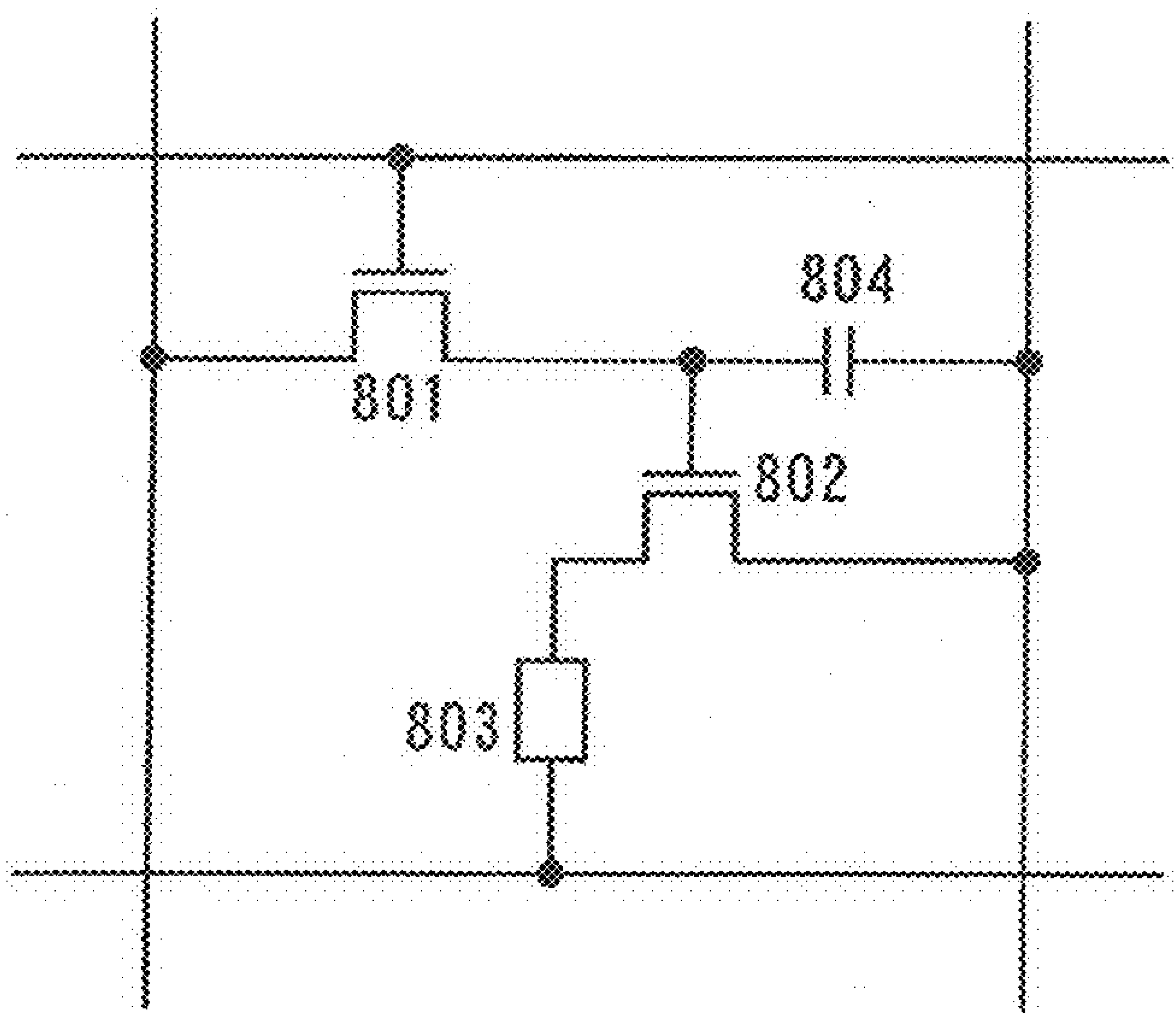


FIG. 8B

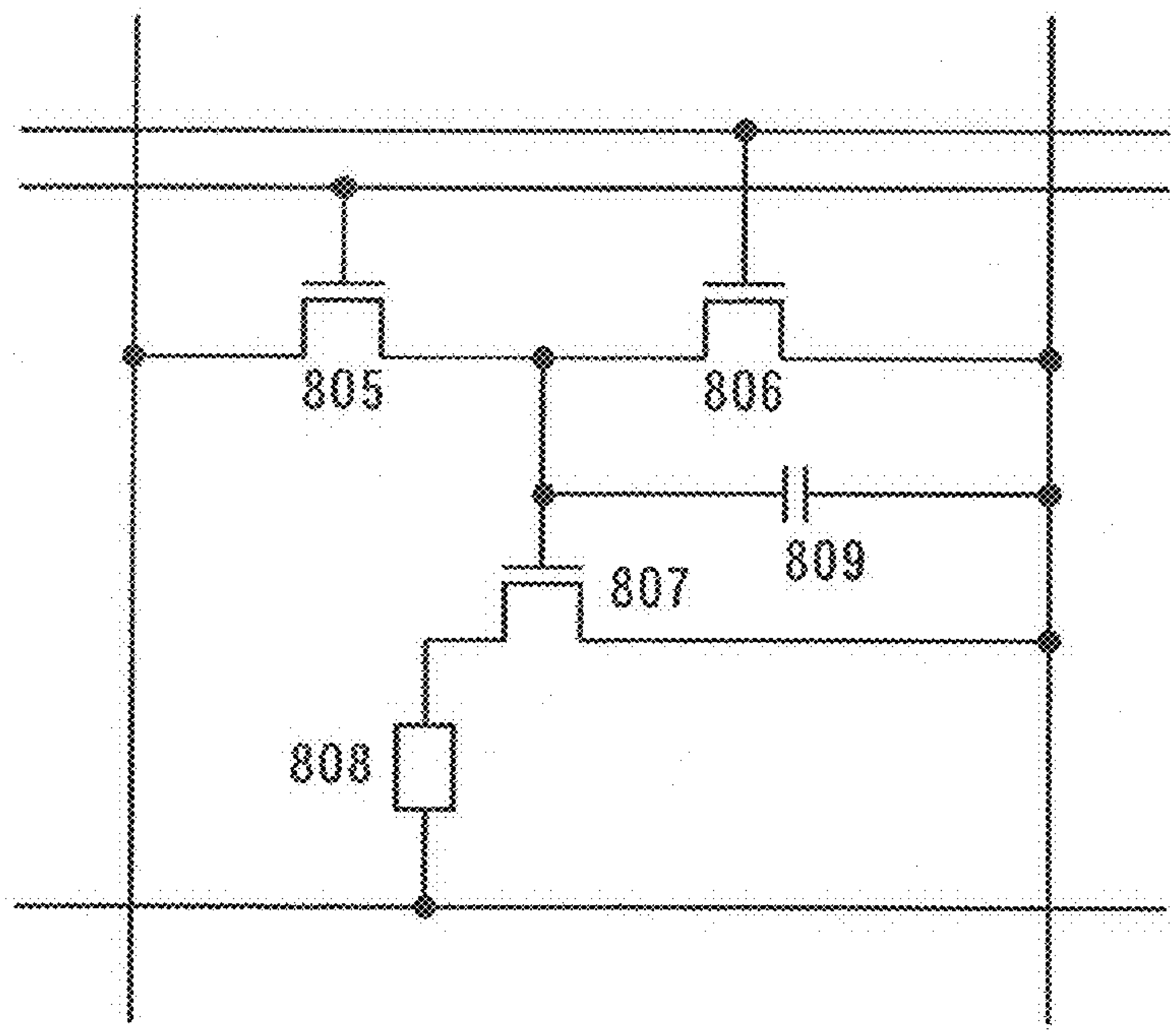


FIG. 9A

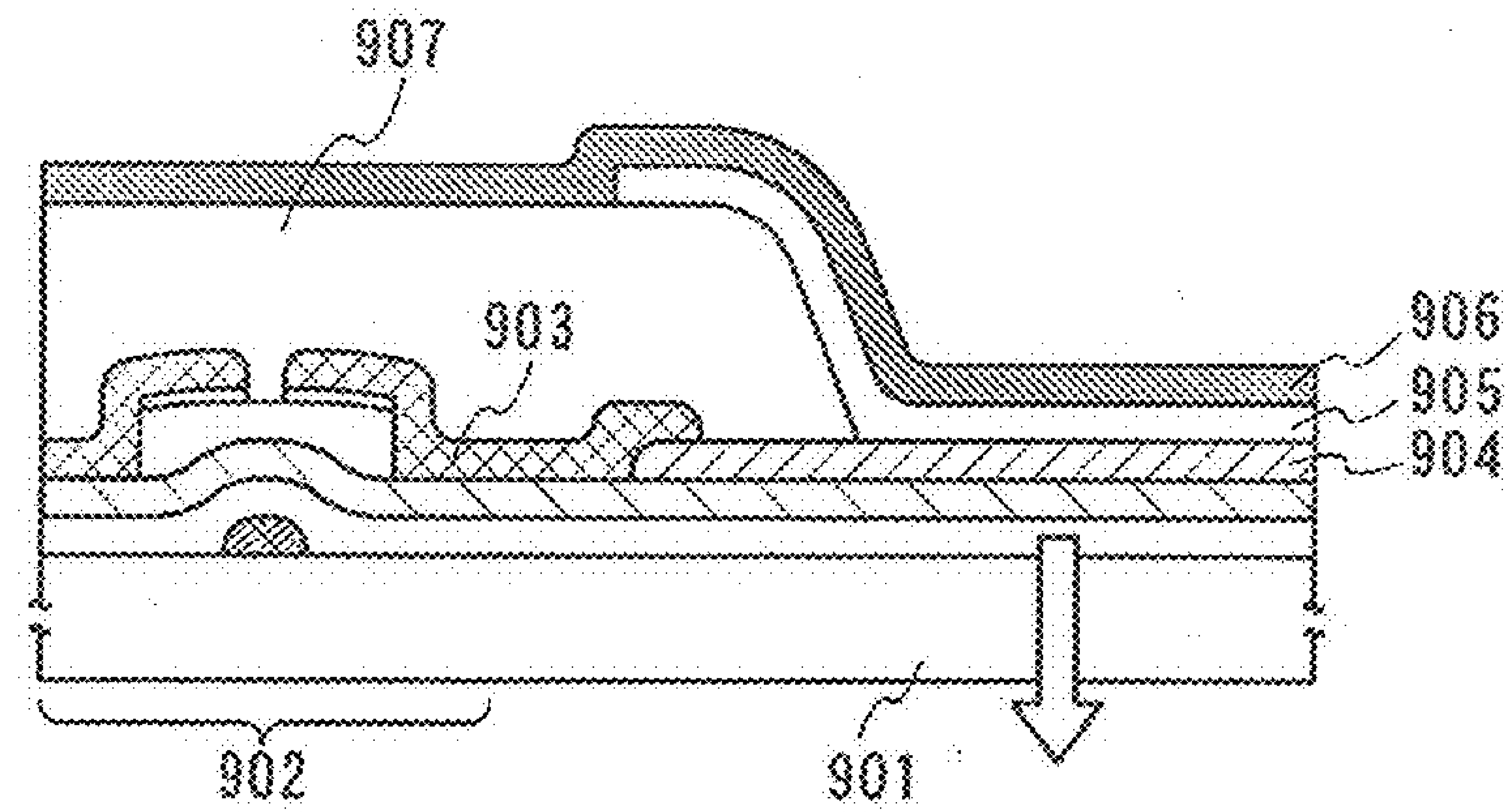


FIG. 9B

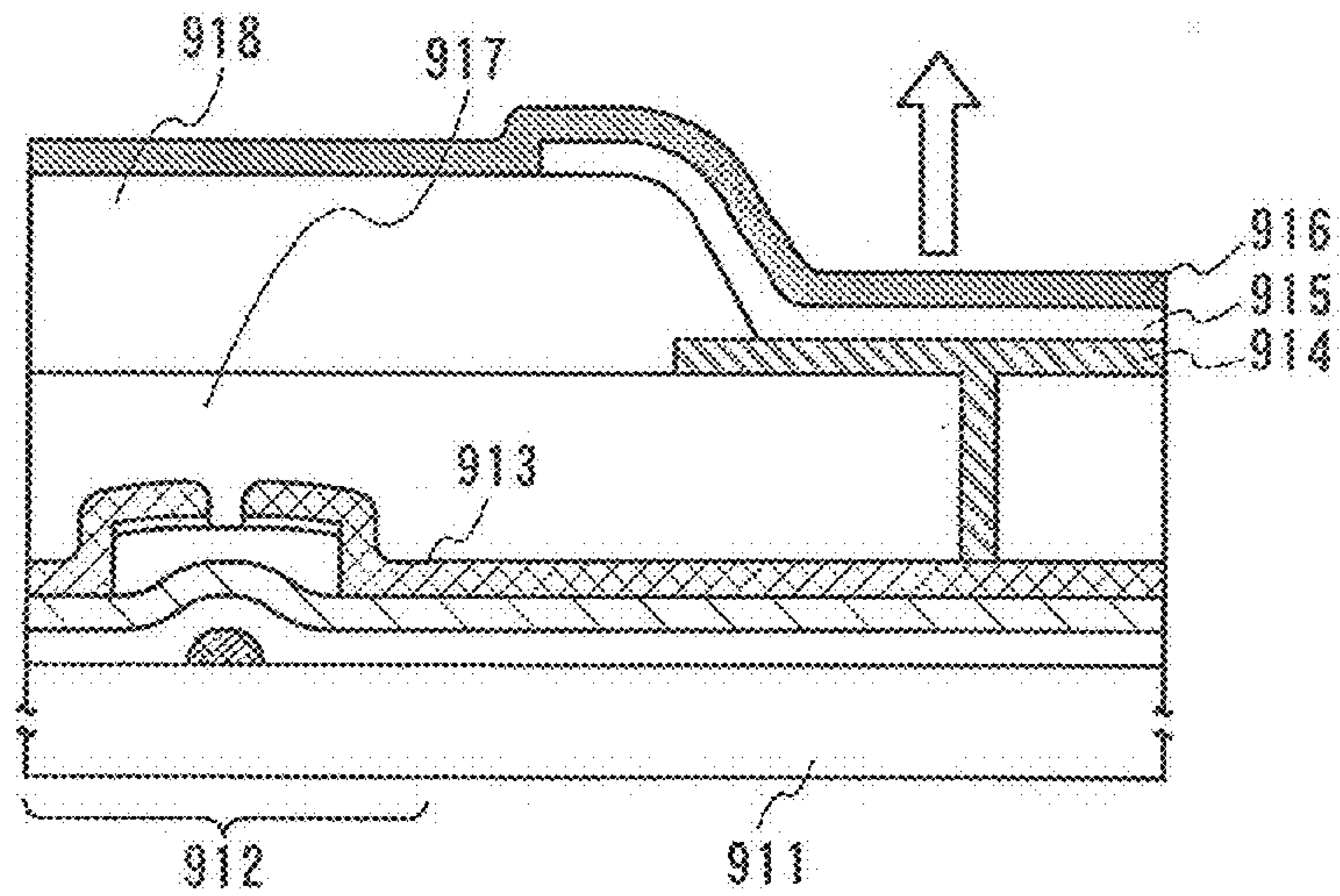


FIG. 9C

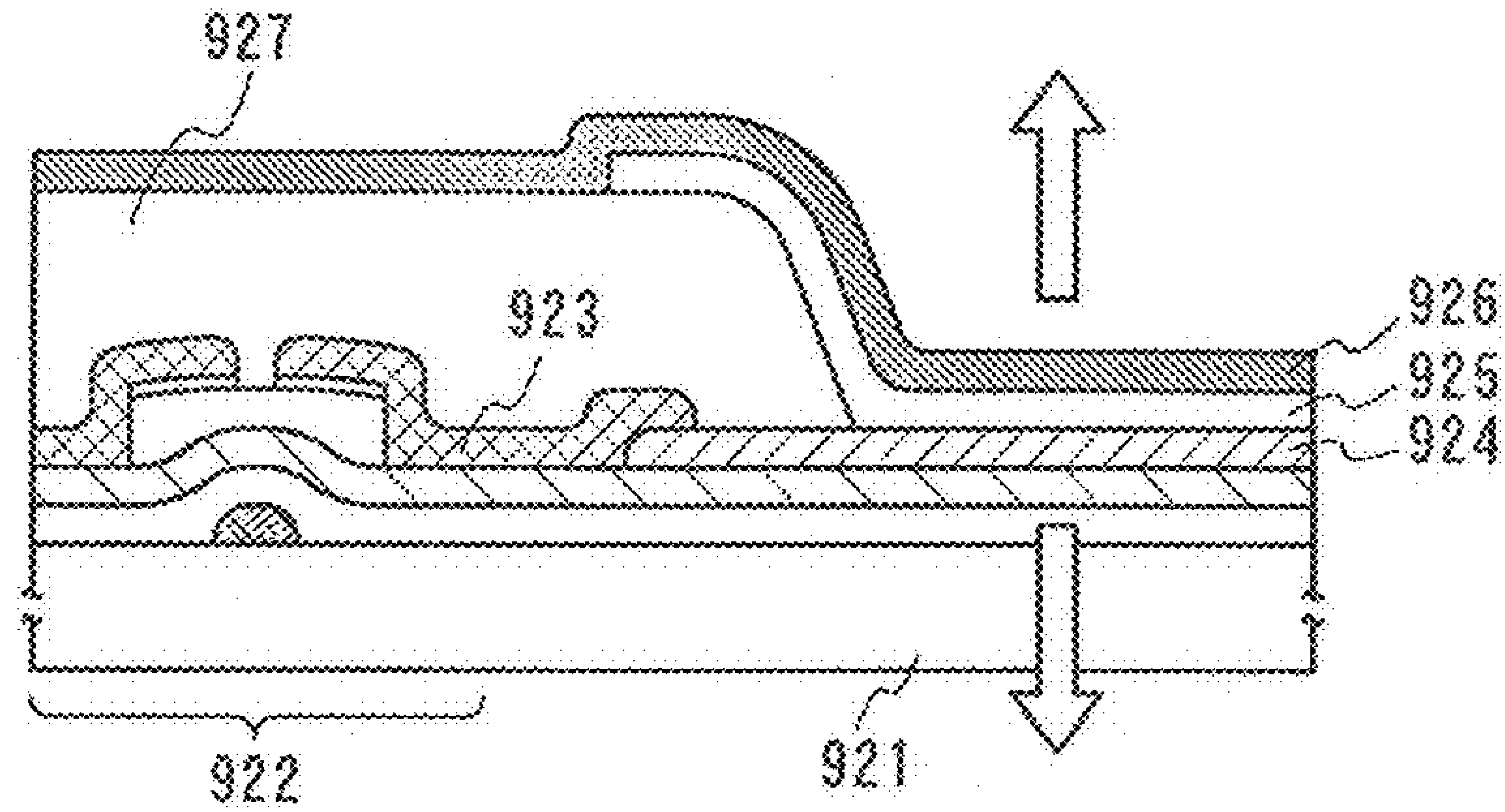


FIG. 10A

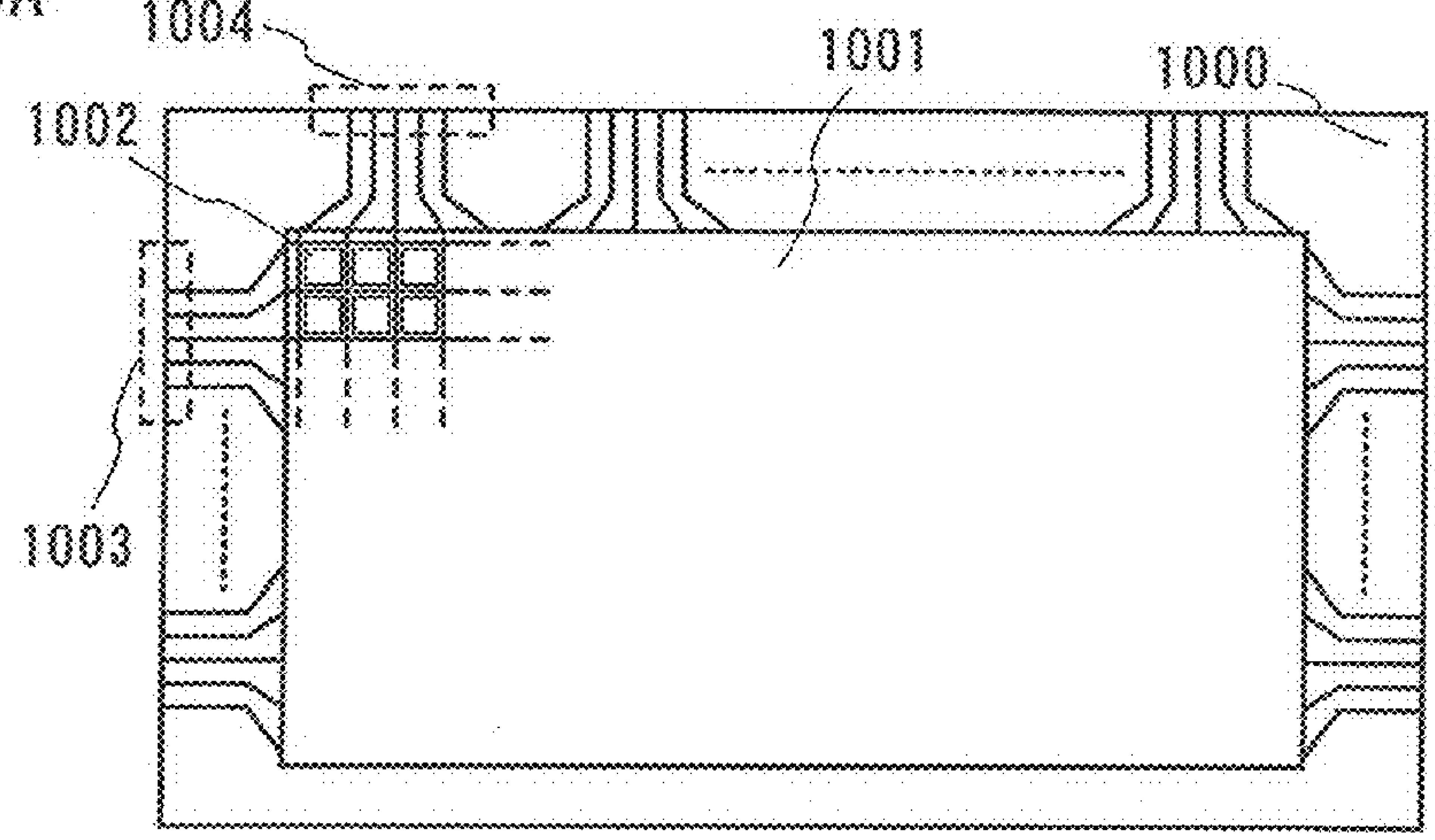


FIG. 10B

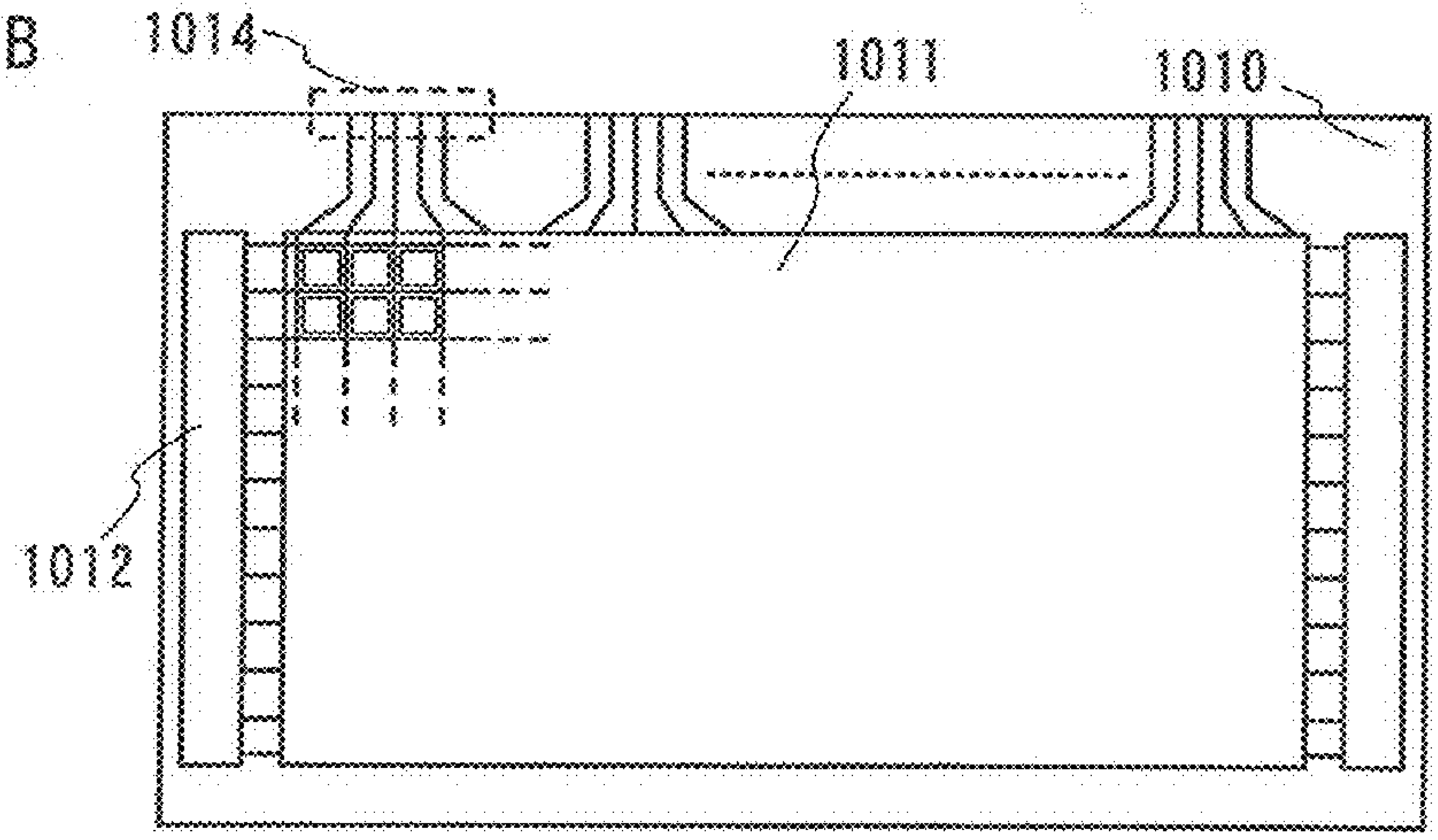
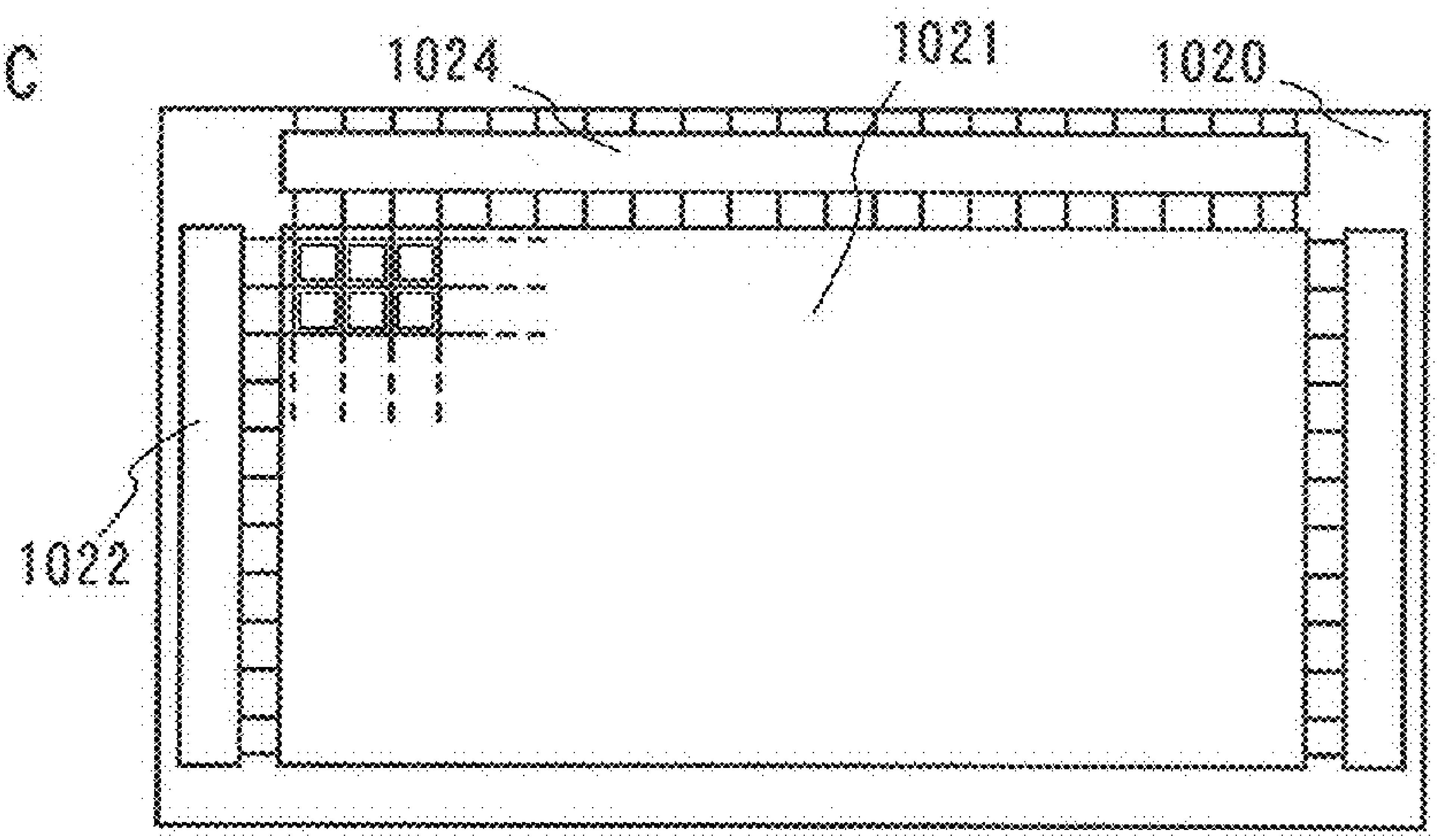


FIG. 10C



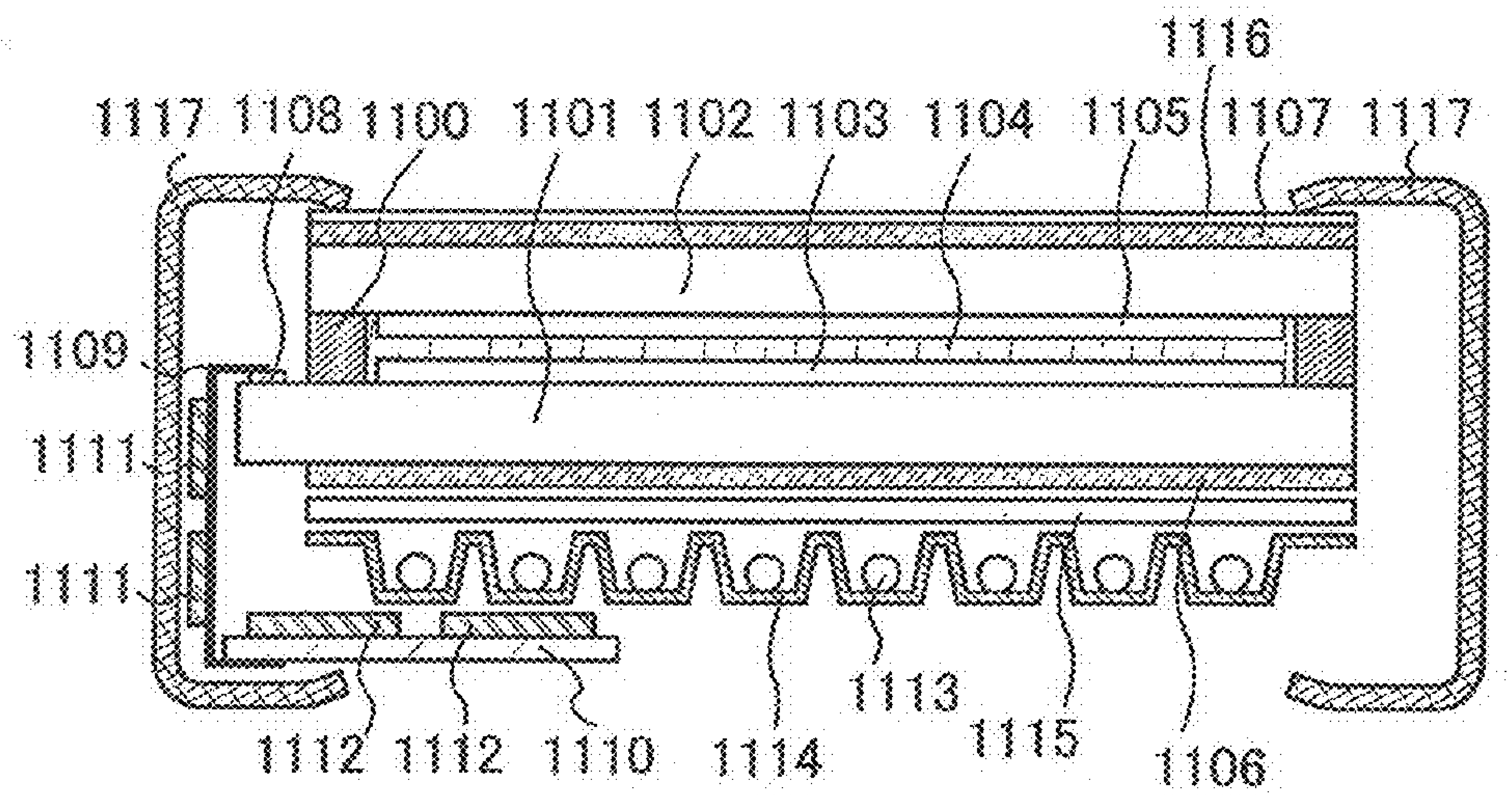

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FIG. 11

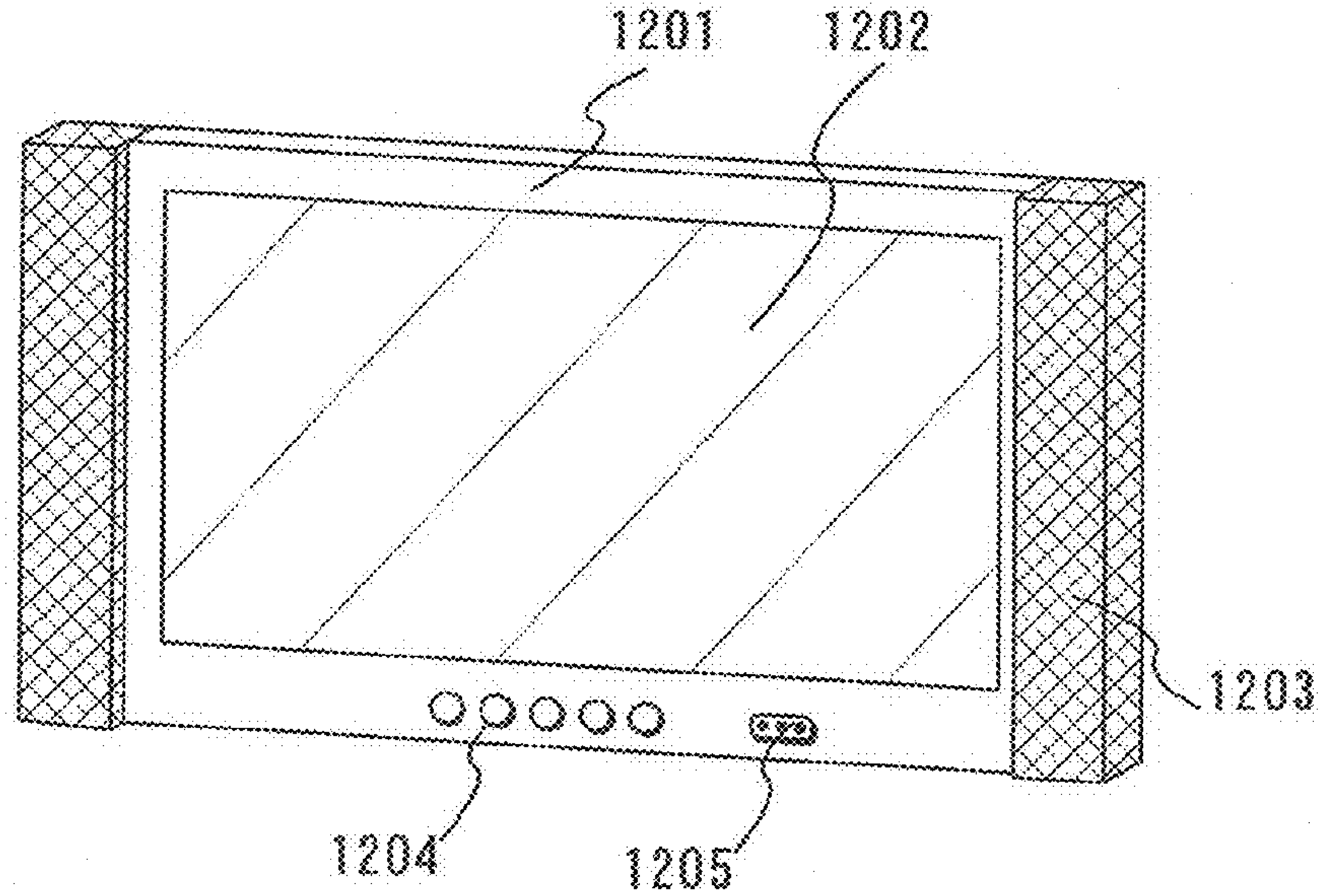


FIG. 12

FIG. 13A

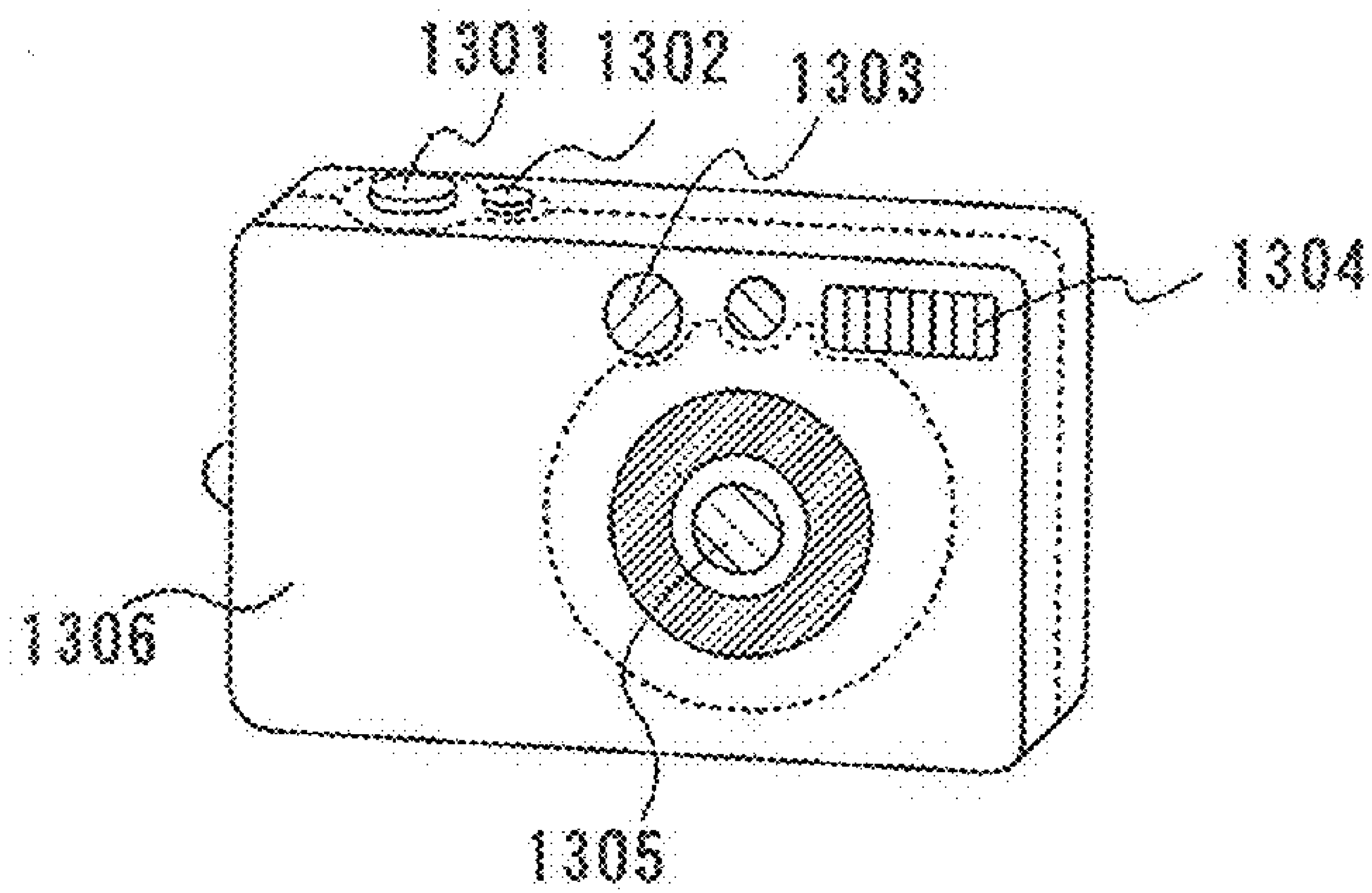
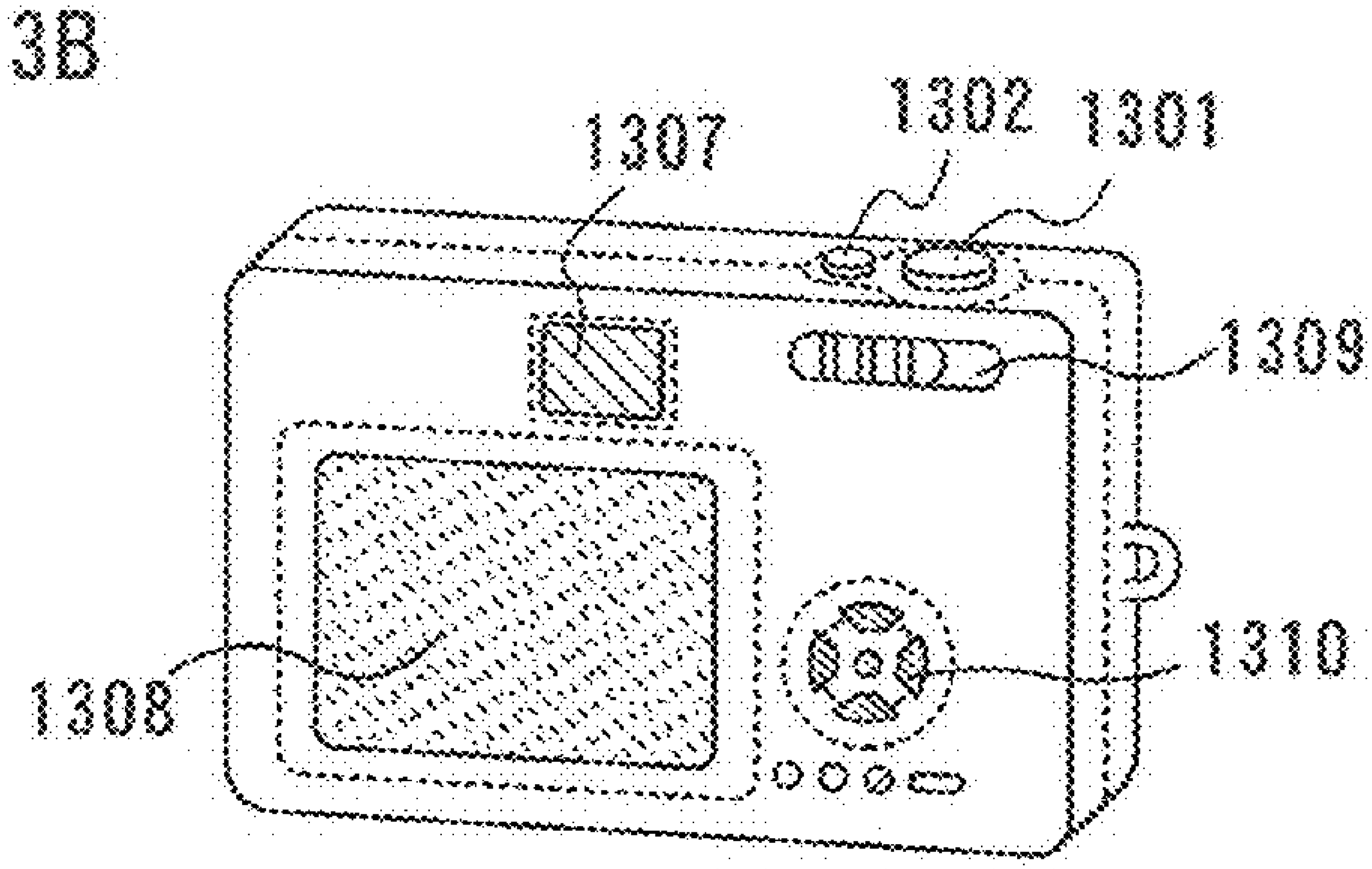


FIG. 13B



DISPLAY DEVICE PROVIDED WITH SEMICONDUCTOR ELEMENT AND MANUFACTURING METHOD THEREOF, AND ELECTRONIC DEVICE INSTALLED WITH DISPLAY DEVICE PROVIDED WITH SEMICONDUCTOR ELEMENT

FIELD OF THE INVENTION

The present invention disclosed in this specification relates to a method for manufacturing a display device provided with a semiconductor element according to a direct drawing process, a display device obtained by the method, and an electronic device installed with the display device. In this specification, a semiconductor element includes a thin film transistor.

DESCRIPTION OF THE RELATED ART

In order to manufacture an amorphous-silicon thin film transistor and a polycrystalline-silicon thin film transistor that are used for a liquid crystal display device and an electroluminescence (EL) display device, a plurality of photomasks is used and a photolithography process is repeated more than once.

In a manufacturing site of a thin film transistor, it is strongly required to reduce the number of photomasks and to omit a photolithography process. Thus, a direct drawing process for foaming a wiring pattern and a film pattern by discharging a droplet using an ink-jet technique or the like is considered as an alternative to a photolithography process as is described in Reference 1 (U.S. Pat. No. 5,132,248) and Reference 2 (Japanese Patent Laid-Open No. 2003-80694). Since a pattern can be formed without requiring a photolithography process by using a method based on the direct drawing process, the number of photomasks can be reduced.

Meanwhile, it is known that the ON-state current and operating speed of a thin film transistor can be increased by making the channel width (usually denoted by W) with respect to the channel length (usually denoted by L), that is, W/L larger. In other words, the ON-state current and operating speed of a thin film transistor can be increased by making the channel width W larger or the channel length L shorter.

In the case of manufacturing a thin film transistor according to a photolithography process, for example, the channel width W can be made larger as well as the channel length L can be made shorter by using a photomask whose mask pattern is changed. However, in the case of manufacturing a thin film transistor according to a direct drawing process by discharging a droplet, it cannot be said yet that a method for making the channel length shorter or the channel width larger without a complicated process is established.

SUMMARY OF THE INVENTION

It is an object of the present invention disclosed in this specification to omit a photolithography process by using a direct drawing process and to obtain a semiconductor element having high ON-state current and high operating speed in a manufacturing process of a display device provided with a semiconductor element.

Two straight lines are drawn to form an electrode or wiring by discharging a fluid (liquid or paste) uniformly dispersed in a predetermined organic solvent, including metal fine particles without being aggregated, by using an ink-jet technique or the like. At that time, when the two straight lines are drawn not to connect with each other, this causes a phenomenon that

each fluid that forms the two straight lines is repelled with each other. This phenomenon is found based on the experience of the inventors.

In addition, a predetermined region is coated with an agent that improves the wettability of the fluid and the fluid is discharged to both of regions where the agent is coated and where the agent is not coated. This case causes a phenomenon that the discharged fluid spreads more in the region where the agent is coated than in the region where the agent is not coated. This is because the wettability of the fluid gets higher in the region where the agent is coated than in the region where the agent is not coated.

Wettability is evaluated by a contact angle of a fluid with respect to a solid surface, and the smaller a contact angle is, the higher the wettability of a fluid is. In this specification, high wettability refers to the case where a contact angle of a fluid with respect to a solid surface is less than 90°. In other words, the contact angle of the fluid in the region coated with the agent is less than 90°. According to the invention disclosed in this specification, it is sufficient that the contact angle of the fluid is smaller in the region where the agent is coated than in the region where the agent is not coated.

A thin film transistor one of semiconductor elements whose channel width W is made larger and channel length L is made shorter can be manufactured by utilizing these phenomena.

According to one invention disclosed in this specification, a display device provided with a semiconductor element comprises a gate electrode or wiring formed over a substrate; an insulating film formed to cover the gate electrode or wiring; a source electrode and a drain electrode formed over the insulating film; and a semiconductor film formed to be in contact with the source electrode, a drain electrode, and the insulating film in a curve sandwiched between the source electrode and the drain electrode, wherein the curve is over the gate electrode or wiring by interposing the insulating film therebetween, and wherein one of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curve therebetween is curved in a concave, and the other end is curved in a convex.

According to another invention disclosed in this specification, a display device provided with a semiconductor element comprises a gate electrode or wiring formed over a substrate; an insulating film formed to cover the gate electrode or wiring; an island-shape first semiconductor film formed over the gate insulating film; source/drain regions formed of a second semiconductor film containing n-type impurities or p-type impurities formed over the first semiconductor film; source electrode and the drain electrode formed in the range of over the source/drain regions to over the gate insulating film; and a curve sandwiched between the source electrode and the drain electrode and between the source/drain regions, wherein the curve is over the gate electrode or wiring by interposing the insulating film and the first semiconductor film therebetween, wherein one of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curve therebetween is curved in a concave, and the other end is curved in a convex, and wherein each ends of the source/drain regions adjacent to each other by interposing the curve therebetween has the same shape as each ends of the source electrode and the drain electrode.

According to another invention disclosed in this specification, a method for manufacturing a display device provided with a semiconductor element comprises the steps of forming a gate electrode or wiring over a substrate; forming an insulating film to cover the gate electrode or wiring; coating a region of the insulating film surface at least overlapped with part of the gate electrode or wiring with an organic agent; discharging a fluid in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are dispersed in an organic solvent by a droplet discharging method in both of regions where the organic agent is coated and left and where the organic agent is not coated of the insulating film surface; forming a source electrode and a drain electrode by baking and hardening the fluid; and forming a semiconductor film to be in contact with the source electrode and the drain electrode along with the insulating film in a curve sandwiched between the source electrode and the drain electrode, wherein the organic agent is coated to improve the wettability of the fluid in the insulating film surface than in the region where the organic agent is not coated, and wherein one of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curve therebetween is formed by being curved in a concave, and the other end is formed by being curved in a convex.

According to another invention disclosed in this specification, a method for manufacturing a display device provided with a semiconductor element comprises the steps of forming a gate electrode or wiring over a substrate; forming an insulating film to cover the gate electrode or wiring; forming a first semiconductor film over the gate insulating film; forming a second semiconductor film containing n-type impurities or p-type impurities over the first semiconductor film; patterning the first semiconductor film and the second semiconductor film each to be an island-shape; coating a region of the island-shape semiconductor film surface at least overlapped with part of the gate electrode or wiring with an organic agent; discharging a fluid in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are dispersed in an organic solvent by a droplet discharging method in both regions where the organic agent is coated and left and where the organic agent is not coated of the gate insulating film surface; forming source electrode and the drain electrode by baking and hardening the fluid; and forming source/drain regions by dry etching the second semiconductor film with the use of the source electrode and the drain electrode as masks, wherein the organic agent is coated to improve the wettability of the fluid in the second semiconductor film surface than in the region where the organic agent is not coated, wherein a curve sandwiched between the source electrode and the drain electrode and between the source/drain regions is formed according to the step of forming the source electrode and the drain electrode and the step of forming the source/drain regions, wherein one of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curve therebetween is formed by being curved in a concave, and the other end is formed by being curved in a convex, and wherein each ends of the source/drain regions adjacent to each other by interposing the curve therebetween has the same shape as each ends of the source electrode and the drain electrode.

According to the invention disclosed in this specification, the channel width W and the channel length L of a semiconductor element can easily be made larger and shorter, respectively. A semiconductor element high in ON-state current and operating speed can be manufactured without a photolithography process or omitting a photolithography process according to the invention disclosed in this specification.

These and other objects, features and advantages of the present invention will become more apparent upon reading of the following detailed description along with the accompanied drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIGS. **1**A to **1**E are cross-sectional views each showing a manufacturing process of a thin film transistor according to Embodiment Mode 1;

FIGS. **2**A to **2**C are top views each showing a manufacturing process of a thin film transistor according to Embodiment Mode 1;

FIGS. **3**A and **3**B are photographs of top views each showing a thin film transistor according to Embodiment Mode 1 and a comparative example;

FIG. **4** is a view showing a V_G–I_D characteristic of a thin film transistor according to Embodiment Mode 1 and a comparative example;

FIGS. **5**A to **5**E are cross-sectional views each showing a manufacturing process of a thin film transistor according to Embodiment Mode 2;

FIGS. **6**A to **6**E are cross-sectional views each showing a manufacturing process of a thin film transistor according to Embodiment Mode 3;

FIGS. **7**A to **7**E are cross-sectional views each showing a manufacturing process of a thin film transistor according to Embodiment Mode 4;

FIGS. **8**A and **8**B are circuit diagrams each showing the pixel portion of an EL display device shown in Embodiment 1;

FIGS. **9**A to **9**C are cross-sectional views each showing the pixel portion of an EL display show in Embodiment 1;

FIGS. **10**A to **10**C are top views each showing a configuration of a display device shown in Embodiment 1;

FIG. **11** is a view showing a liquid crystal display device shown in Embodiment 1;

FIG. **12** is a view showing an electronic device shown in Embodiment 2; and

FIGS. **13**A and **13**B are views each showing an electronic device shown in Embodiment 2.

DETAILED DESCRIPTION OF THE INVENTION

Embodiment Modes 1 to 4 hereinafter described will explain a manufacturing process of a thin film transistor which is a semiconductor element and a manufactured thin film transistor.

Embodiment Mode 1

As shown in FIG. **1**A, a gate electrode (wiring) **102** is formed over a substrate **101**. Although FIG. **1**A shows a cross-sectional shape of the gate electrode (wiring) **102** to be convex, the cross-section of the gate electrode (wiring) **102** is not limited to the convex shape. The substrate may be any one substrate of a glass substrate, a quartz substrate, or a plastic substrate. An example of using a method for forming a pattern having a predetermined shape by discharging the droplet of a fluid from a minute hole (hereinafter, referred to as a droplet discharging method in this specification) is hereinafter described as a method for forming the gate electrode (wiring) **102**. A method using an ink-jet technique is a typical example of the droplet discharging method. The droplet discharging method described in this specification is not necessarily limited to the method using an ink-jet technique.

A fluid (liquid or paste) in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are contained and the fine particles are dispersed in a solvent is discharged over a substrate from, for example, an ink-jet head to form a predetermined shape. In this embodiment, the fluid is discharged in a straight line. Thereafter, the gate electrode is formed by baking and hardening the discharged fluid. After hardening the fluid, although the upper surface of the gate electrode to be formed sags downward and the cross-section sometimes becomes a concave, there is particular no problem.

In order to harden the fluid completely, baking temperatures over 150° C. are necessary. However, in the case where the conductive fine particles contained in the fluid contain silver as the main component, the fine particles lose the density and becomes porous, and thus, the surface is in a rough state when the baking temperatures are over 300° C. Therefore, the baking temperatures have to be below 300° C. Although one hour is enough for the baking time, the time is not necessarily limited to one hour as long as a fluid is hardened completely.

It is a necessary condition for the fluid that the conductive fine particles are uniformly dispersed in the solvent without being aggregated. For example, conductive metal paste described in Japanese Patent Laid-Open No. 2002-299833 or Japanese Patent Laid-Open No. 2002-324966 satisfies the condition. Although the fine particles containing silver as the main component is given as an example of the conductive fine particles contained in the fluid, the conductive fine particles are not limited to silver as long as the fluid can be used as an electrode or wiring after the baking. For example, fine particles containing as the main component any one of gold, copper, an alloy of gold and silver, an alloy of gold and copper, an alloy of silver and copper, or an alloy of gold, silver, and copper may also be used. Alternatively, fine particles containing conductive oxide such as indium tin oxide (ITO) as the main component may also be used.

A known sputtering method or vacuum vapor deposition method may also be used as a method for forming the gate electrode (wiring) **102**. Alternatively, the gate electrode (wiring) **102** may be formed by a screen printing method instead of the droplet discharging method.

Then, as shown in FIG. **1**B, a gate insulating film **103** is formed over the gate electrode (wiring) **102** and the substrate **101**. For example, a polyimide film can be used as the gate insulating film **103**. The polyimide film can be formed by a spin-coating method, which is formed by performing baking at temperatures below 200° C., specifically at 180° C. for one hour after performing spin coating. The polyimide film can also be formed by using a droplet discharging method instead of the spin-coating method. Further, another organic resin film or an inorganic insulating film such as silicon oxide or silicon nitride may also be used instead of the polyimide film.

As shown in FIG. **1**C, a surface region **104** of the gate insulating film **103** is coated with an organic agent. The region **104** is a region at least overlapped with part of the gate electrode (wiring) **102** and a region of the surface of the gate insulting film **103** at least over the gate electrode (wiring) **102**. FIG. **2**A shows a top view in order to show relation of the gate electrode (wiring) **102** and the region **104**. The droplet discharging method can be used as a method for coating an organic agent.

A high boiling point agent such as tetradecane, decanol, or octanol whose boiling point is over 150° C. that does not volatilize easily at a room temperature is preferably used for the organic agent that is coated. However, after coating the organic agent, it is desired that the organic agent does not remain behind as much as possible when the fluid is baked to form a source electrode and a drain electrode as will be described hereinafter. The organic agent for coating is desirable to be one whose boiling point is below 300° C. On the other hand, a low boiling point agent such as acetone or ethanol whose boiling point is below 100° C. that is dried soon after the coating is inappropriate for the present invention disclosed in this specification.

In addition, the same organic solvent as that contained in the fluid used to form a source electrode and a drain electrode is used as the organic agent for coating the region **104**. Accordingly, the wettability of the fluid can certainly be improved.

For example, in the case of using a fluid in which conductive fine particles are dispersed in tetradecane, the region **104** is coated with tetradecane, and in the case of using a fluid in which conductive fine particles are dispersed in decanol, the region **104** is coated with decanol. However, it is sufficient that the organic agent for coating the region **104** is a high boiling point agent capable of improving the wettability of the fluid; therefore, the organic agent does not necessarily need to be the same as the organic solvent contained in the fluid.

After coating the organic agent as described above, a fluid (liquid or paste) in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are contained and the fine particles are dispersed in an organic solvent is discharged by using a droplet discharging method again with the organic agent left in the region **104** to draw a predetermined shape. It is sufficient that the same fluid as that used in forming the gate electrode (wiring) **102** is used for the fluid.

FIG. **2**B shows a top view of after the drawing. Reference numeral **201** and **202** in FIG. **2**B each denote fluids to be a source electrode and a drain electrode by being baked and hardened. The fluids **201** and **202** each show that the fluids are discharged in the region **104** where the organic agent is coated and left and a region where the organic agent is not coated. Since the fluids **201** and **202** have the higher wettability in the region **104** than the region where the organic agent is not coated, the fluids spreads in a direction along the surface of the gate insulating film **103**.

The fluids **201** and **202** spread in the region **104** in the foregoing manner. Although this causes to make the fluids **201** and **202** closer with each other, the fluids never connect because both fluids are repelled with each other.

Thereafter, the fluids **201** and **202** are baked at temperatures over 150° C. for a predetermined time to be hardened. Accordingly, a source electrode and a drain electrode **105** and **106** shown in FIG. **1**D are formed. After baking, it is desirable that the organic agent coated to the region **104** does not remain.

Then, as shown in FIG. **1**E, a semiconductor film **107** is formed. For example, pentacene which is a p-type organic semiconductor having a shape in which five benzene rings are linearly joined is vapor-deposited with a metal mask as the semiconductor film **107**. As shown in FIG. **1**E, the semiconductor film **107** is formed to be in contact with the source electrode and the drain electrode **105** and **106** along with the gate insulating film **103** between the source electrode and the drain electrode **105** and **106**.

Instead of the vapor-deposition, the pentacene may be formed by using a droplet discharging method or a screen printing method. Further, another organic semiconductor may be used instead of the pentacene. The semiconductor film **107** may be formed of a silicon film by a known CVD method instead of the organic semiconductor like pentacene. The crystallinity of the silicon film in this case is not particularly limited.

FIG. **2**C is a top view showing a shape of the source electrode and the drain electrode **105** and **106**. A channel length L and a channel width W are shown by an arrow in FIG. **2**C. There is a curve (curved space) sandwiched between the source electrode and the drain electrode **105** and **106** over the gate electrode (wiring) **102**. The channel length L corresponds to the width of the curved space (average of the width when the width is not uniform), and the channel width W corresponds to the length of the curved space along the curve.

One of each ends **203** and **204** of the source electrode and the drain electrode **105** and **106** adjacent to each other by interposing the curve (curved space) therebetween is curved in a concave, and the other end is curved in a convex. Then, in order to follow the concave curve of the one end, the other end is curved in a convex.

FIGS. **3**A and **3**B each show a photograph of a top view showing a thin film transistor. The thin film transistor is formed by using a glass substrate as the substrate, the source electrode and the drain electrode **105** and **106** and the gate electrode **102** that are formed by a droplet discharging method with the use of the fluid in which fine particles containing silver as the main component is contained and the fine particles are dispersed in tetradecane, a polyimide film in 120 nm thick as the gate insulating film, and the pentacene film in 50 nm thick as the semiconductor film. According to these photographs, the gate electrode **102** and the source electrode and the drain electrode **105** and **106** formed thereover can be distinguished.

FIG. **3**A shows a thin film transistor formed according to this embodiment mode, in which a process of discharging tetradecane by using a droplet discharging method in a region of the polyimide film surface at least overlapped with the gate electrode **102** is performed before forming the source electrode and the drain electrode **105** and **106**. FIG. **3**B is a comparative example, which is different from FIG. **3**A in that a thin film transistor is formed by omitting the process of discharging tetradecane to the polyimide film surface.

The thin film transistor shown in FIG. **3**A has the channel width W of 350 and the channel length L of 50 μm (W/L=350/50), and the thin film transistor shown in FIG. **3**B has the channel width W of 100 μm and the channel length L of 300 μm (W/L=100/300). In the thin film transistor shown in FIG. **3**A, apparently, the channel length L is shorter and the channel width W is larger; therefore, the ON-state current and the operating speed of the thin film transistor are higher than those of the thin film transistor shown in FIG. **3**B.

FIG. **4** shows measured results of a V_G–I_D characteristic of the thin film transistors each shown in FIGS. **3**A and **3**B whose gate voltage V_G is represented in a horizontal axis and drain current I_D is represented in a vertical axis, when the drain voltage V_D of the thin film transistors are −3V and −5V, respectively. Since a p-channel thin film transistor in which pentacene is used for a semiconductor film is measured, the drain current I_D actually takes a minus value; thus, the vertical axis in FIG. **4** is represented by $-I_D$.

Paying attention to the range of $V_G \leqq -3V$, the $-I_D$ value of the thin film transistor whose W/L value is 350/50 is larger than that of the thin film transistor whose W/L value is 100/300. This result indicates that the former thin film transistor has higher ON-state current than the latter thin film transistor.

Not limiting to this embodiment mode, the invention disclosed in this specification is suitable for the case of forming a thin film transistor with low mobility using an amorphous semiconductor, a microcrystal semiconductor, or an organic semiconductor for a channel-forming region. This is because thin film transistors using these semiconductor materials usually has low mobility of 5 cm^2/Vsec or less; therefore, the thin film transistors have to be designed to have large W/L, value to increase the ON-state current. Not only in the case of a thin film transistor using the above semiconductors but also in the case of a thin film transistor using polycrystalline silicon for a channel-forming region, the invention disclosed in this specification contributes in increasing the ON-state current and operating speed of the thin film transistors.

In addition, not limiting to this embodiment mode, the invention disclosed in this specification is suitable for the case of applying the invention to a display device such as a liquid crystal display device. For example, a gate insulating film is coated with an organic agent for improving the wettability of a fluid so as not to step over a region overlapped with a gate electrode (wiring). Accordingly, the fluid does not spread in the region where the organic agent is not overlapped with the gate electrode. Therefore, a source electrode and a drain electrode formed by hardening the fluid never glows in width in the region where the organic agent is not coated and not overlapped with the gate electrode. Accordingly, the channel width W of the thin film transistor can be made larger without decreasing the aperture ratio. This is because the aperture ratio is not affected even the source electrode and the drain electrode get wider only in a region overlapped with a region where the gate electrode is formed because light is not transmitted and can be shielded in the region where the gate electrode is formed.

In addition, according to this embodiment mode, a thin film transistor can be manufactured without a photolithography process and a photomask used in the process.

Embodiment Mode 2

In this embodiment mode, which is different from Embodiment Mode 1, a semiconductor film such as silicon will be used instead of an organic semiconductor like pentacene as a semiconductor film.

As shown in FIG. **5**A, a gate electrode (wiring) **502** is formed over any one substrate **501** of a glass substrate, a quartz substrate, or a plastic substrate. As shown in Embodiment Mode 1, a droplet discharging method is preferably used for a method for forming the gate electrode (wiring) **502**. Of course, the gate electrode (wiring) **502** may be formed by using another methods.

Then, a film composed of a skeleton structure formed by the bond of silicon and oxygen (hereinafter, referred to as a heat-resistant planarizing film in this specification) is formed as a first layer **503** of a gate insulating film. The heat-resistant planarizing film has higher heat resistance than an organic resin film and is obtained by coating and baking siloxane-based polymer by a spin-coating method or the like so that the gate electrode (wiring) **502** and the substrate **501** are covered therewith. The siloxane-based polymer may be coated by using a droplet discharging method instead of the spin-coating method. The first layer **503** is formed in 100 nm thick, for example. In addition, a silicon nitride film, a silicon oxide film, or a silicon oxynitride film may also be formed by a CVD method as the first layer **503**.

Further, a silicon nitride film is formed over the first layer **503** by a CVD method as a second layer **504** of the gate insulating film. The second layer **504** is formed in 200 nm thick, for example. A method for forming the second layer **504** is not limited to the CVD method and the second layer **504** may be formed by another methods. In addition, the second layer **504** is not limited to the silicon nitride film and, for example, the second layer **504** may also be a silicon oxide film or a silicon oxynitride film. However, the second layer **504** and the first layer **503** are formed from different materials. Note that the gate insulating film may be formed of only one layer instead of the two layers in the foregoing manner.

As shown in FIG. **5**B, a first semiconductor film **505** is formed. An amorphous semiconductor film is formed over the second layer **504** of the gate insulating film by a CVD method with the use of a source gas such as silane (SiH_4) to obtain the first semiconductor film **505**. The first semiconductor film **505** may be a crystalline semiconductor film by crystallizing the amorphous semiconductor film that is formed.

A specific example of a method for crystallizing the amorphous semiconductor film is shown. First, an amorphous silicon film is formed by a CVD method as the amorphous semiconductor film. Thereafter, the amorphous silicon film is coated with a solution containing a metal element that promotes crystallization of the silicon film, for example, nickel, and then heated in a furnace, for example, at 550° C. for four hours to perform solid phase growth.

Since the crystalline silicon film that is formed contains the metal element, treatment to be referred to as gettering is performed to remove the metal element. In other words, after removing an oxide film in the surface of the crystalline silicon film that is formed, at least one layer, for example, two layers of an amorphous silicon film containing phosphorus are formed and reheated in a furnace; therefore, the metal element is diffused from the crystalline silicon film to the amorphous silicon film containing phosphorus. It is sufficient that the heating condition is the same as that for the solid phase growth. Accordingly, the crystalline silicon film whose concentration of the metal element is reduced is obtained.

Besides the method in which the solid phase growth and the gettering process are combined, the amorphous semiconductor film may be crystallized by using a method for irradiating an amorphous semiconductor film with a laser beam, a method for performing rapid thermal annealing (referred to as RTA) to an amorphous semiconductor film, or a method in which any of the three methods are arbitrarily combined.

The first semiconductor film **505** may also be a so-called microcrystal semiconductor film. The microcrystal semiconductor film has an intermediated structure between an amorphous structure and a crystal structure (including a single crystalline structure and a polycrystalline structure) and includes a crystalline region having a short-range order along with lattice distortion. A crystalline region of from 0.5 nm to 20 nm can be observed at least in part of the region in the film. In the case of the microcrystal semiconductor film, Raman spectrum is shifted to a lower wave number side less than 520 cm^{-1}. Diffraction peak of (111) or (220) to be caused from a crystal lattice of silicon is observed in X-ray diffraction. The microcrystal semiconductor film is formed by performing glow discharge decomposition (plasma CVD) with a silicide gas, for example, SiH_4, Si_2H_6, $Si_2H_2Cl_2$, $SiHCl_3$, $SiCl_4$, or SiF_4 under deposition temperatures below 300° C. F_2 or GeF_4 may be mixed into the silicide gas.

A second semiconductor film **506** containing n-type impurities (phosphorus or arsenic) is formed over the first semiconductor film **505**. The second semiconductor film **506** may also contain p-type impurities (boron) instead of the n-type impurities or along with the n-type impurities. The crystallinity of the second semiconductor film **506** may be any of an amorphous state, a microcrystalline state, or a polycrystalline state. In addition, the silicon film containing phosphorus in which the metal element is diffused by performing the gettering treatment can be used as the second semiconductor film **506**. Accordingly, there is no necessity to remove the silicon film containing phosphorus in which the metal element is diffused.

As shown in FIG. **5**C, an island-shape first semiconductor film **505***a* and an island-shape second semiconductor film **506***a* is obtained by patterning the first semiconductor film **505** and the second semiconductor film **506**. The patterning may be performed by a known photolithography method and further the patterning can also be performed without a photomask by using a laser direct drawing apparatus.

Then, a region **507** in the surface of the second semiconductor film **506** that is patterned in an island-shape is coated with an organic agent with a high boiling point agent whose boiling point is over 150° C. like tetradecane, decanol, or octanol. The region **507** coated with the organic agent is a region at least overlapped with part of the gate electrode (wiring) **502**. The organic agent to be coated to the region **507** has to be able to improve the wettability of a fluid subsequently used to form a source electrode and a drain electrode.

As shown in FIG. **5**D, a source electrode and a drain electrode **508** and **509** are formed by using a droplet discharging method in the same manner as Embodiment Mode 1. It is sufficient that a fluid shown in Embodiment Mode 1 is used for the fluid to be discharged. For example, the source electrode and the drain electrode **508** and **509** containing silver as the main component are formed after discharging, from an ink-jet head or the like, a fluid in which fine particles containing silver as the main component whose grain size is 1 nm or more and 100 nm or less are contained and the fine particles are dispersed in tetradecane, and then baking the fluid under a predetermined condition to be hardened.

Under a condition to leave the fluid in the region **507**, the fluid is discharged in the region **507** and the surface of the second layer **504** of the gate insulating film where the organic agent is not coated. The discharged fluid spreads along the surface of the second semiconductor film **506**; therefore, the source electrode and the drain electrode **508** and **509** having the same shape as that in Embodiment Mode 1 is obtained. In other words, there is a curve (curved space) sandwiched between the source electrode and the drain electrode **508** and **509** over the gate electrode (wiring) **502**. One of each ends of the source electrode and the drain electrode **508** and **509** adjacent to each other by interposing the curved space therebetween is curved in a concave, and the other end is curved in a convex. Then, in order to follow the concave curve of the one end, the other end is curved in a convex.

As shown in FIG. **5**E, source/drain regions **510** and **511** are formed by etching the second semiconductor film **506** that is patterned in an island-shape, using the source electrode and the drain electrode **508** and **509** as masks. At the time of the etching, a dry etching method capable of anisotropic etching is used. In addition, the surface of the first semiconductor film **505** may be partially etched along with the second semiconductor film **506**. Accordingly, a so-called channel-etch thin film transistor is formed. In such a case, the etching has to be performed under a condition not to expose the surface of the second layer **504** of the gate insulating film. The source/drain regions **510** and **511** that are formed have the same curved shape as the source electrode and the drain electrode **508** and **509**.

In the same manner as Embodiment Mode 1, a thin film transistor that is obtained according to this embodiment mode including a process of coating the region **507** with the organic agent has the shorter channel length L and the larger channel width W.

Embodiment Mode 3

This embodiment mode will show an example in which a thin film transistor shown in Embodiment Mode 1 is formed in a double-gate structure.

As shown in FIG. **6**A, gate electrodes (wirings) **602** and **603** are formed over any one substrate **601** of a glass substrate, a quartz substrate, or a plastic substrate by using a droplet discharging method, for example.

As shown in FIG. **6**B, a polyimide film is formed as a gate insulating film **604** over the gate electrodes (wirings) **602** and **603** and the substrate **601** by a spin-coating method, for example. In the same manner as Embodiment Mode 1, the gate insulating film **604** is not limited to the polyimide film.

As shown in FIG. **6**C, regions **605** and **606** in the surface of the gate insulating film **604** is coated with an organic agent by using a droplet discharging method, for example. The region **605** is a region at least overlapped with part of the gate electrode (wiring) **602**, and the region **606** is a region at least overlapped with part of the gate electrode (wiring) **603**. The organic agent to be coated to the regions **605** and **606** are a high boiling point agent shown in Embodiment Mode 1.

As shown in FIG. **6**D, a source electrode and a drain electrode **607**, **608**, and **609** are formed over the gate insulating film **604** by a droplet discharging method. The regions where the source electrode and the drain electrode **607**, **608**, and **609** are formed in the regions **605** and **606** where the organic agent is coated and a region where the organic agent is not coated, over the gate insulating film **604**.

As shown in FIG. **6**E, a semiconductor film **610** is formed by forming an organic semiconductor such as pentacene with the use of a vapor-deposition method, a droplet discharging method, or a screen printing method. The semiconductor film **610** is not limited to the organic semiconductor and a silicon film may be formed by using a CVD method. The crystallinity of the silicon film in this case is not particularly limited. The semiconductor film **610** is formed to be in contact with the source electrode and the drain electrode **607**, **608**, and **609** along with the gate insulating film **604** between the source electrode and the drain electrode **607** and **608** and the gate insulating film **604** between the source electrode and the drain electrode **608** and **609**.

There is a curve (curved space) sandwiched between the source electrode and the drain electrode **607** and **608** over the gate electrode (wiring) **602**. In addition, there is a curve (curved space) sandwiched between the source electrode and the drain electrode **608** and **609** over the gate electrode (wiring) **603**. One of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curved spaces therebetween is curved in a concave, and the other end is curved in a convex. Then, in order to follow the concave curve of the one end, the other end is curved in a convex.

The OFF-state current of a thin film transistor can be reduced much more than a single-gate structure shown in Embodiment Mode 1 by employing the double-gate structure shown in this embodiment mode.

Embodiment Mode 4

This embodiment mode will show an example in which a thin film transistor shown in Embodiment Mode 2 is formed in a double-gate structure.

As shown in FIG. **7**A, gate electrodes (wirings) **702** and **703** are formed over any one substrate **701** of a glass substrate, a quartz substrate, or a plastic substrate by using a droplet discharging method, for example.

Then, for example, a film composed of a skeleton structure formed by the bond of silicon and oxygen (a heat-resistant planarizing film) is coated and baked with siloxane-based polymer by a spin-coating method or the like as a first layer **704** of a gate insulating film. Further, for example a silicon nitride film is formed as a second layer **705** of the gate insulating film. In the same manner as Embodiment Mode 2, the first layer **704** and the second layer **705** may be formed by using another insulating film. However, the second layer **704** and the first layer **703** are formed from different materials. The gate insulating film may be formed of only one layer instead of the two layers in the foregoing manner.

As shown in FIG. **7**B, for example, an amorphous silicon film is formed over the second layer **705** of the gate insulating film by a CVD method as a first semiconductor film **706**. The crystallinity of the first semiconductor film **706** is not limited to an amorphous state and may also be a microcrystalline state or a polycrystalline state. For example, a microcrystalline silicon film containing n-type impurities is formed over the first semiconductor film **706** as a second semiconductor film **707**. Alternatively, the second semiconductor film **707** may also contain p-type impurities. In addition, the crystallinity of the second semiconductor film **707** is not limited to a microcrystalline state and may be any one of an amorphous state or a polycrystalline state.

As shown in FIG. **7**C, island-shape first semiconductor films **706***a* and **706***b* and island-shape second semiconductor films **707***a* and **707***b* is obtained by patterning the first semiconductor film **706** and the second semiconductor film **707**. The first semiconductor film **706** and the second semiconductor film **707** can be patterned without a photomask by using a laser direct drawing apparatus.

Then, regions **708***a* and **708***b* in each surface of the island-shape second semiconductor films **707***a* and **707***b* are coated with an organic agent. The region **708***a* is a region at least overlapped with part of the gate electrode (wiring) **702**, and the region **708***b* is a region at least overlapped with part of the gate electrode (wiring) **703**. The organic agent to be coated to the regions **708***a* and **708***b* has to be a high boiling point agent that can improve the wettability of a fluid subsequently used to form source electrode and the drain electrode and that does not dry soon after the coating.

As shown in FIG. **7**D, a source electrode and a drain electrode **709**, **710**, and **711** are formed by using an ink jetting technique. A fluid in which fine particles containing silver as the main component whose grain size is 1 nm or more and 100 nm or less are contained and the fine particles are dispersed in tetradecane can be used for the fluid to be discharged. The source electrode and the drain electrode **709**, **710**, and **711** are formed in the range of over the regions **708***a* and **708***b* to over the second layer **705** of the gate insulating film where the organic agent is not coated.

There is a curve (curved space) sandwiched between the source electrode and the drain electrode **709** and **710** over the gate electrode (wiring) **702**. In addition, there is a curve (curved space) sandwiched between the source electrode and the drain electrode **710** and **711** over the gate electrode (wiring) **703**. One of each ends of the source electrode and the drain electrode adjacent to each other by interposing the curved spaces therebetween is curved in a concave, and the other end is curved in a convex. Then, in order to follow the concave curve of the one end, the other end is curved in a convex.

As shown in FIG. **7**E, source/drain regions **712**, **713**, **714**, and **715** are formed by etching the island-shape second semiconductor films **707***a* and **707***b*, using the source electrode and the drain electrode **709**, **710**, and **711** as masks. At the time of the etching, a dry etching method capable of anisotropic etching is used. The source/drain regions **712**, **713**, **714**, and **715** that are formed have the same curved shapes as the source electrode and the drain electrode **709**, **710**, and **711**.

The OFF-state current of a thin film transistor can be reduced much more than a single-gate structure shown in Embodiment Mode 2 by employing the double-gate structure shown in this embodiment mode.

In Embodiment Modes 1 to 4 explained in the foregoing manner, a bottom-gate thin film transistor is formed. However, the present invention disclosed in this specification is not limited to the bottom-gate thin film transistor and can also be applied to a so-called forward stagger thin film transistor in which a gate electrode is provided over a channel-forming region.

Embodiment 1

A thin film transistor, one of semiconductor elements, that is formed according to the present invention disclosed in this specification, is applied to various display devices. For example, a liquid crystal display device and an electroluminescence (EL) display device are given as an example of the display device to which the thin film transistor is applied; however, the display device is not limited thereto as long as the display device is a display device using the thin film transistor.

FIGS. **8**A and **8**B are circuit diagrams each showing an example of the pixel portion of an electroluminescence (EL) display device. Note that the pixel portion of the electroluminescence (EL) display device is not limited to these two examples.

FIG. **8**A shows a type of a pixel portion having two thin film transistors in each pixel. Reference numerals **801** and **802** each denote a thin film transistor, and a light-emitting element **803** is connected to the source/drain electrode of the thin film transistor **802**. Reference numeral **804** denotes a capacitor element. For example, the thin film transistor **801** is an n-channel type, and the thin film transistor **802** is a p-channel type. In the thin film transistor **801**, the gate electrode is connected to a scanning line, and the source/drain electrode is connected to a signal line.

FIG. **8**B shows a type of a pixel portion having three thin film transistors in each pixel. Reference numerals **805**, **806**, and **807** each denote a thin film transistor, and a light-emitting element **808** is connected to the source/drain electrode of the thin film transistor **807**. Reference numeral **809** denotes a capacitor element. For example, the thin film transistor **805** is an n-channel type, the thin film transistor **806** is an n-channel type, and the thin film transistor **807** is a p-channel type. In the thin film transistor **805**, the gate electrode is connected to a scanning line, and the source/drain electrode is connected to a signal line.

The invention disclosed in this specification can be applied to the thin film transistors of the pixel portions each shown in FIGS. **8**A and **8**B.

FIGS. **9**A, **9**B, and **9**C each show an example of the pixel portion of an electroluminescence (EL) display device in a cross-sectional view. FIGS. **9**A, **9**B, and **9**C each show a thin film transistor formed according to Embodiment Mode 2 and a light-emitting element electrically connected to the source/drain electrode of the thin film transistor over any one substrate of a glass substrate, a quartz substrate, or a plastic substrate.

In FIG. **9**A, reference numeral **901** denotes a substrate; **902**, a thin film transistor; **903**, a source/drain electrode; **904**, a light-transmitting first electrode; **905**, an electroluminescent layer; **906**, a second electrode; and **907**, an insulating film. FIG. **9**A shows a so-called bottom-emission type in which generated light is emitted to the substrate **901** side (bottom side).

In FIG. **9**B, reference numeral **911** denotes a substrate; **912**, a thin film transistor; **913**, a source/drain electrode; **914**, a first electrode; **915**, an electroluminescent layer; **916**, a light-transmitting second electrode; and **917** and **918**, insulating films. FIG. **9**B shows a so-called top-emission type in which generated light is emitted to an opposite side of the substrate **911** (top side).

In FIG. **9**C, reference numeral **921** denotes a substrate; **922**, a thin film transistor; **923**, a source/drain electrode; **924**, a light-transmitting first electrode; **925**, an electroluminescent layer; **926**, a light-transmitting second electrode; and **927**, an insulating film. FIG. **9**C shows a so-called dual emission type in which generated light is emitted both to an opposite side of the substrate **921** (top side) and to the substrate **921** side (bottom side).

Indium tin oxide (ITO), indium tin oxide containing silicon oxide, or indium zinc oxide (IZO) containing zinc oxide and indium oxide can be used as the light-transmitting first electrode or second electrode, which can be formed by a sputtering method or a droplet discharging method.

In the insulating films **907**, **918**, and **927** each shown in FIGS. **9**A, **9**B, and **9**C, an opening that reaches the surface of the first electrode are each formed. It is preferable that the cross-section of each opening has a shape whose curvature radius continuously changes to be roundish in order to improve coverage of the electroluminescent layer and the second electrode. An inorganic insulating film such as silicon oxide or silicon nitride, an organic resin film such as polyimide, or the foregoing heat-resistant planarizing film that is obtained by coating and baking siloxane-based polymer can be used as the insulating films **907**, **917**, **918**, and **927**.

In each of FIGS. **9**A, **9**B, and **9**C, one of the first electrode and the second electrode corresponds to an anode, and the other one to a cathode. When the first electrode is an anode and the second electrode is a cathode, a hole transporting layer, an organic emitting layer, and an electron transporting layer are sequentially stacked in the electroluminescent layers **905**, **915**, and **925**. On the other hand, when the first electrode is a cathode and the second electrode is an anode, an electron transporting layer, an organic emitting layer, and a hole transporting layer are sequentially stacked in the electroluminescent layers **905**, **915**, and **925**. A hole injecting layer may be provided between the anode and the hole transporting layer, and an electron injecting layer may be provided between the cathode and the electron transporting layer. The organic emitting layer can be formed by using any one of a droplet discharging method, a printing method, or a vacuum vapor-deposition method, and either a high molecular weight light-emitting material or a low molecular weight light-emitting material can also be used.

The invention disclosed in this specification can be applied to not only a thin film transistor used for the pixel portion of an electroluminescence (EL) display device but also when a scanning-line driver circuit and a signal-line driver circuit are each formed with a thin film transistor. High-speed operation is required for the thin film transistor used for these driver circuits. Therefore, since the thin film transistor having the long channel width W according to the invention disclosed in this specification has high ON-state current and high operation speed, the thin film transistor is suitable for the use of the drivers.

FIGS. **10**A, **10**B, and **10**C are top views each showing a structure of a display device such as a liquid crystal display device or an electroluminescence (EL) display device to which the invention disclosed in this specification is applied.

In FIG. **10**A, a pixel portion **1001** in which a plurality of pixels **1002** is arranged in matrix, a scanning-line input terminal **1003**, and a signal-line input terminal **1004** are formed over a substrate **1000**. A scanning line extending from the scanning-line input terminal **1003** and a signal line extending from the signal-line input terminal **1004** are intersected with each other; therefore, the pixels **1002** are arranged in matrix. Each pixel **1002** is provided with a switching element and a pixel electrode. A typical example of the switching element is a thin film transistor. FIG. **10**A exemplifies a display device in which signals inputted into the scanning line and the signal line are controlled by a driver circuit connected to exterior of the substrate via the scanning-line input terminal **1003** and the signal-line input terminal **1004**. However, a COG method for forming a driver circuit over a substrate may also be used.

FIG. **10**B is an example in which a pixel portion **1011** and a scanning-line driver circuit **1012** are formed over a substrate **1010**. Reference numeral **1014** denotes a signal-line input terminal which is the same as that in FIG. **10**A. In addition, FIG. **10**C is an example in which a pixel portion **1021**, a scanning-line driver circuit **1022**, and a signal-line driver circuit **1024** are formed over a substrate **1020**.

The scanning-line driver circuit **1012** shown in FIG. **10**B and the scanning-line driver circuit **1022** and the signal-line driver circuit **1024** each shown in FIG. **10**C are each formed with a thin film transistor, which can be formed simultaneously with the thin film transistors provided in the pixel portions. However, high-speed operation is required for the scanning-line driver circuit and the signal-line driver circuit. Therefore, a thin film transistor using a microcrystalline semiconductor film or a polycrystalline semiconductor film which has higher mobility than an amorphous semiconductor film for the channel-forming region has to be selected as a thin film transistor used for these circuits.

A thin film transistor manufactured according to the invention disclosed in this specification can be applied at least to the pixel portions shown in FIGS. **10**A, **10**B, and **10**C, and can also be applied to the scanning-line driver circuit **1012** shown in FIG. **10**B and to the scanning-line driver circuit **1022** and the signal-line driver circuit **1024** shown in FIG. **10**C.

A thin film transistor manufactured according to the invention disclosed in this specification can be applied not only to an electroluminescence (EL) display device but also at least to the pixel portion and further to the driver circuit of a liquid crystal display device.

In this embodiment, FIG. **11** shows one example of a liquid crystal display device to which the invention disclosed in this specification is applied. The liquid crystal display device is not limited to the example shown in FIG. **11**.

A liquid crystal layer **1104** is provided between a first substrate **1101** and a second substrate **1102**, and the substrates adhere to each other with a sealant **1100**. A pixel portion **1103** is formed in the first substrate **1101**, and a colored layer **1105** is formed in the second substrate **1102**. The colored layer **1105**, which is necessary in performing color display, is provided with colored layers corresponding to each color of red, green, and blue corresponded to each pixel in the case of a RGB method. Polarizing plates **1106** and **1107** are each provided on the outer sides of the first substrate **1101** and the second substrate **1102**. In addition, a protective film **1116** is formed on the surface of the polarizing plate **1107** to relieve impact from the exterior.

A thin film transistor is formed in the pixel portion **1103**, and the thin film transistor according to the invention disclosed in this specification can be applied.

A wiring board **1110** is connected to a connected terminal **1108** provided for the first substrate **1101** via an FPC **1109**. The FPC **1109** or a connection wiring is provided with driver circuits **1111** (an IC chip or the like), and the wiring board **1110** is provided with an external circuit **1112** such as a control circuit or a power supply circuit.

A cold cathode tube **1113**, a reflection plate **1114**, and an optical film **1115** are each a backlight unit, which serve as a light source. The first substrate **1101**, the second substrate **1102**, the light source, the wiring board **1110**, and the FPC **1109** are held and protected by a bezel **1117**.

Embodiment 2

This embodiment will show an electronic device on which a display device described in Embodiment 1 is mounted. The following can be given as an example of the electronic devices on which the display device is mounted: a television apparatus, a camera such as a digital camera, a personal computer, a cellular phone device, and the like. However, the display device to which the present invention disclosed in this specification is applied is not limited to the case where the display device is mounted on these electronic devices.

FIG. **12** shows one example of the television apparatus. Reference numeral **1201** denotes a casing; **1202**, a display portion; **1203**, a speaker; **1204**, an operation portion; and **1205**, a video input terminal. The display device to which the invention disclosed in this specification is applied is used for the display portion **1202**.

FIGS. **13**A and **13**B show one example of the digital camera. FIG. **13**A is a view showing the digital camera from a front face, and reference numeral **1301** denotes a release button; **1302**, a main switch; **1303**, a viewfinder window; **1304**, a stroboscope; **1305**, a lens; and **1306**, a casing. FIG. **13**B is a view showing the digital camera from back face, and reference numeral **1307** denotes a viewfinder eyepiece; **1308**, a monitor; and **1309** and **1310**, operation buttons. The display device to which the invention disclosed in this specification is applied is used for the monitor **1308**.

The invention disclosed in this specification can be applied not only to the television apparatus and the digital camera but also to an electronic device having a display portion and a monitor.

The present application is based on Japanese Patent Application serial No. 2004-241119 filed on Aug. 20, 2004 in Japanese Patent Office, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. A method for manufacturing a display device comprising the steps of:

forming a gate electrode over a substrate;

forming an insulating film over the gate electrode;

coating a region of the insulating film surface at least overlapped with part of the gate electrode with an organic agent;

discharging a fluid in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are dispersed in an organic solvent by a droplet discharging method in a region where the organic agent is coated and left and a region of the insulating film where the organic agent is not coated;

baking and hardening the fluid to form a source electrode and a drain electrode; and

forming a semiconductor film to be in contact with the source electrode, the drain electrode and the insulating film in a curve sandwiched between the source and drain electrodes,

wherein the organic agent is coated to improve wettability of the fluid in the insulating film surface than in the region where the organic agent is not coated.

2. A method for manufacturing a display device comprising the steps of:

forming a gate electrode over a substrate;

forming an insulating film to cover the gate electrode;

forming a first semiconductor film over the insulating film;

forming a second semiconductor film containing an impurity element over the first semiconductor film;

patterning the first semiconductor film and the second semiconductor film each to be an island-shape;

coating a region of the island-shape semiconductor film surface at least overlapped with part of the gate electrode with an organic agent;

discharging a fluid in which conductive fine particles whose grain size is 1 nm or more and 100 nm or less are dispersed in an organic solvent by a droplet discharging method in a region where the organic agent is coated and left and a region where the organic agent is not coated;

baking and hardening the fluid to form a source electrode and a drain electrode; and

forming a source region and a drain region by dry etching the second semiconductor film with the use of the source electrode and the drain electrode as masks,

wherein the organic agent is coated to improve wettability of the fluid in the second semiconductor film surface than in the region where the organic agent is not coated.

3. The method for manufacturing a display device according to claim **1**, wherein the semiconductor film is formed by using an organic semiconductor.

4. The method for manufacturing a display device according to claim **2**, wherein the insulating film is formed of a first layer and a second layer formed over the first layer which is formed from different material from that of the first layer.

5. The method for manufacturing a display device according to claim **2**, wherein the impurity element is a p-type impurity element.

6. The method for manufacturing a display device according to claim **2**, wherein the impurity element is an n-type impurity element.

7. The method for manufacturing a display device according to claim **1**, wherein one of each ends of the source and drain electrodes adjacent to each other by interposing the curve therebetween is formed by being curved in a concave, and the other end is formed by being curved in a convex.

8. The method for manufacturing a display device according to claim **2**, wherein a curve sandwiched between the source and drain electrodes and between the source and drain regions is formed according to said forming the source electrode and the drain electrode and said forming the source region and the drain region,

wherein one of side edges of the source electrode and the drain electrode which is opposed to each other with the curve interposed therebetween is formed by being curved in a concave, and the other end is formed by being curved in a convex,

wherein a side edge of the source region which is opposed to a side edge of the drain region has the same shape as the side edge of the source electrode, and

wherein the side edge of the drain region has the same shape as the side edge of the drain electrode.

9. The method for manufacturing a display device according to claim **1**, wherein the curve is a curved space.

10. The method for manufacturing a display device according to claim **8**, wherein the curve is a curved space.

11. A method for manufacturing a display device comprising the steps of:

forming a wiring over a substrate;

forming an insulating film over the wiring;

coating a part of the insulating film with an organic agent wherein the part of the insulating film is overlapped with the wiring;

forming a first film by discharging a fluid to the insulating film such that a part of the first film is overlapped with the part of the insulating film;

forming a second film by discharging a fluid to the insulating film such that a part of the second film is overlapped with the part of the insulating film; and

forming a third film over the first film and the second film wherein the third film is in contact with the part of the insulating film.

12. A method according to claim **11**, wherein the first film is a conductive film.

13. The method according to claim **11**, wherein the second film is a conductive film.

14. The method according to claim **11**, wherein the third film is a semiconductor film.

15. A method for manufacturing a display device comprising the steps of:

forming a gate electrode over a substrate;

forming an insulating film over the gate electrode;

coating a part of the insulating film with an organic agent wherein the part of the insulating film is overlapped with the gate electrode;

forming a first film by discharging a fluid to the insulating film such that a part of the first film is overlapped with the part of the insulating film;

forming a second film by discharging a fluid to the insulating film such that a part of the second film is overlapped with the part of the insulating film; and

forming a third film over the first film and the second film wherein the third film is in contact with the part of the insulating film.

16. The method according to claim **15**, wherein the first film is a conductive film.

17. The method according to claim **15**, wherein the second film is a conductive film.

18. The method according to claim **15**, wherein the third film is a semiconductor film.

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